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Blast Furnace By-Products and Their Possible Recovery.

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ABOUT fifteen years ago the writer, in his lectures on the Manufacture of Iron and Steel, in connection with the City and Guilds of London Institute, used to refer to the blast furnace as being one of the most economical and nearly theoretically perfect processes existent; at that time the possibilities of the recovery of by-products not being realised to the fullest extent. Since then keen competition has rendered a more careful examination in the chemistry and recovery of by-products necessary to make the possible profit on the pig-iron product higher by means of turning them to useful account.

At that time, fifteen years ago, there was no idea that the principal product of the furnace might possibly become, through the profitable recovery of the by-products, a secondary consideration in regard to the means of returning a respectable dividend, though, in one case at least, the profits obtainable from the recovery of certain by-products has turned the scale, and saved the works from being abandoned. While pig-iron may still be considered the principal product of the blast furnace, the following list of by-products, the profitable recovery of which has been demonstrated in many cases, will be of great interest to the owners and managers of blast furnaces, as in some cases the profit accruing from the recovery of one or more of these products has enabled iron-works to be carried on which otherwise would have had to be closed down.

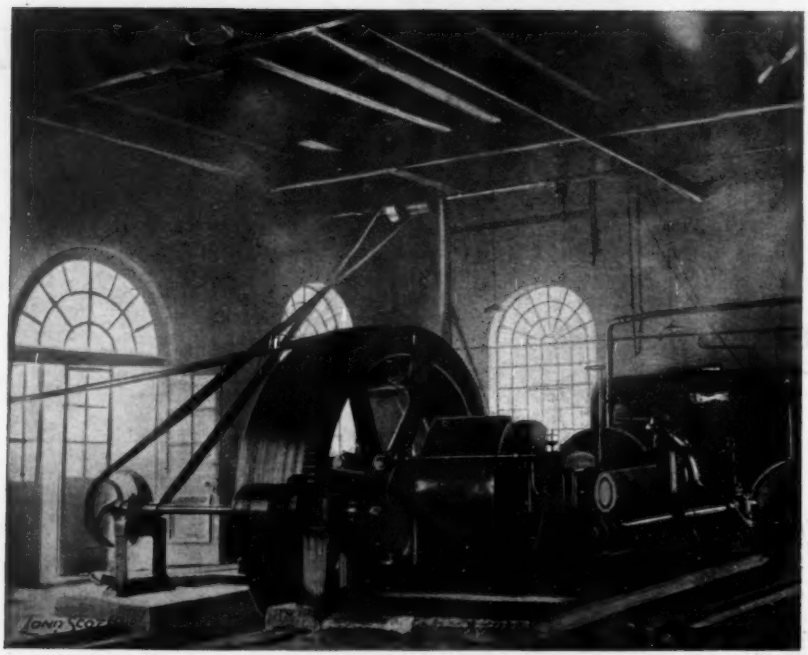
The by-products from the blast furnace may be briefly tabulated thus:

Leaving the Blast Furnace.	By-products.
I. Molten pig-iron ...	Sensible and latent heat.
II. ,, slag ...	,, ,, ,,
—	Slag, various applications.
III. Dust carried out by the gases ...	... Various applications.
—	Zinc.
IV. Gases ...	... Sensible heat.
—	Combustible heat.
—	Ammonia.
—	Tar.
—	Oil.

It will be interesting to deal with these in the order as tabulated.

I. *Sensible and latent heat of the molten iron as it leaves the furnace.*—The temperature of molten pig-iron is variously stated by different workers, but it will probably not be far from the truth if we take 2,000 degs. Fahr. as the temperature, and the specific heat ·11 degs.; also latent heat 282 degs. One ton of molten iron as it leaves the furnace therefore carries out:

Pounds.	Spec. Heat.			
2,240 ×	·11 ×	1,967° Fahr.	484,669	B Th. U.
2,240 ×	282 ..	... ...	631,680	,,
		Total ...	1,116,349	,



BLAST FURNACE GAS ENGINE DRIVING DYNAMO.

At the present time, under existing conditions, the sensible heat, besides being entirely wasted, when the metal is cast on the pig-bed, is a source of great inconvenience to the workmen. Where the metal can be taken in a molten state to steel furnaces, or metal mixers, a very considerable portion of the sensible and latent heat is turned to good account. As a matter of fact, the conveyance of the molten metal a couple of miles, in ladles, only reduces the temperature about 130 degs. Fahr.

Taking the heating power of coke, when burned to carbonic acid, as 13,000 B.Th.U. per lb., 1,116,349 B.Th.U. is equivalent to 86 lbs. coke per ton of pig-iron leaving the furnace, and if the metal is conveyed direct to Bessemer converters, or open-hearth furnaces, almost the whole of the sensible and latent heat is turned to useful account, which is equivalent to a saving of nearly 86 lbs. of coke per ton of pig iron, or, with coke at 20s. per ton, this is equivalent to 9d. per ton.

In the blast furnace the whole of the coke does not arrive at the tuyères to be burned to carbonic acid, but rather the equivalent of coke burned to carbonic oxide, with its lower thermal value, would represent the proportional greater amount of coke per ton of pig-iron saved.

At blast furnaces, where a portion of the metal is run directly into foundry castings, there is a saving of sensible and other heat units, due to the fact of the metal not having been run into pig-iron and cooled down to the temperature of the atmosphere, then remelted, the thermal loss due to cooling and remelting being saved.

To melt a ton of pig-iron in a foundry cupola requires about 265 lbs. of coke.

Each ton of pig-iron run direct from the blast furnace into foundry casting

represents a saving over casting into pigs on the big-bed of:—

Per ton of metal.	Coke saved.
Saving due to retaining sensible and latent heat...	86 lbs.
Saving due to metal not requiring melting in a cupola	265 ,,
	351 ,,
Saving per ton of metal with coke at 20/- per ton.	3/1

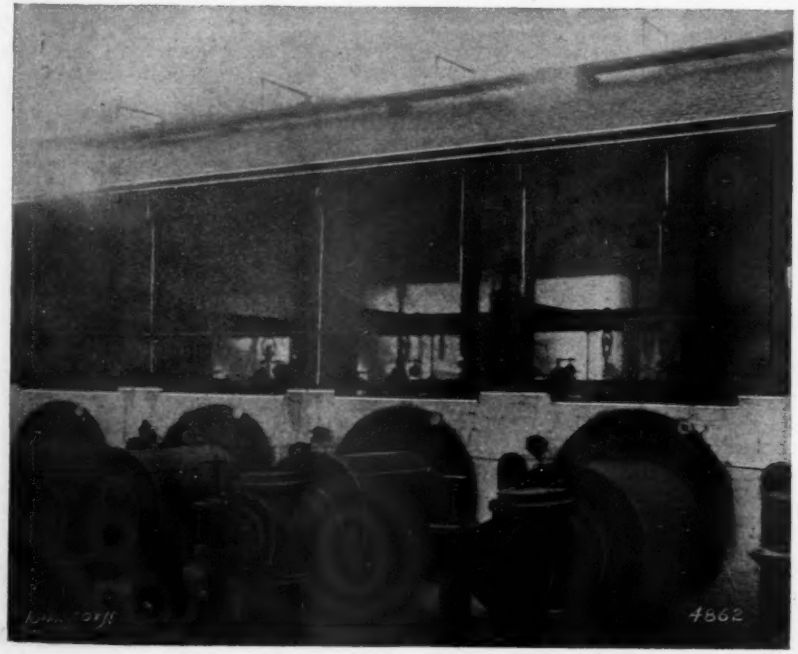
Where steel furnaces are associated with the blast furnaces, and the molten metal is run direct into Bessemer or Siemens' furnaces, a very considerable economy is effected, as, for instance, in the Talbot process of manufacture of open hearth steel.

II. *Sensible and latent heat of the slag leaving the furnace in a molten state.*—Each ton of slag leaving the blast furnace at a temperature of about 2,822 degs. Fahr., having a specific heat of ·25 and latent heat of 108, represents on its reduction to atmospheric temperature—

2,240 × ·25 × ·2,800	...	1,568,000	B.Th.U.
2,240 × 108	... ...	241,920	,,
	Total	1,809,920	,,

—and comparing this with its equivalent of coke at 13,000 B.Th.U. per lb. = 138 lbs. of coke. The proportion of slag, varying as it does in different localities from 10 to 30 cwt. per ton of pig-iron, therefore carries off heat equivalent to from 69 lbs. to 207 lbs. of coke per ton of iron produced.

A portion of this heat has been recovered at certain ironworks by employing it for the evaporation of brine; but generally the slag is removed to some dumping ground, and no attempt is made to recover the sensible and latent heat. As the slag is tapped, or run from the blast furnace, its melting-point being so comparatively high, it rapidly commences to set, and in its



BOILERS FIRED BY BLAST-FURNACE GAS. CLAY CROSS IRONWORKS.

plastic or partly molten state it is very unwieldy.

However, a method has been devised for using a portion of the heat contained in the slag for driving off the moisture from the iron ore to be smelted, and this is an important step in regard to the prevention of waste of heat.

In regard to the slag, however, besides the possibilities in the way of heat recovery, it is, when cooled to atmospheric temperature, in many cases capable of being turned to profitable account.

For road-making material it has a considerable demand; in some localities 1s. per ton, or even higher, is paid for its supply for this purpose; and seeing that per ton of pig iron the slag weight is from half to one and a-half tons, this is equivalent to from 6d. to 1s. 6d. per ton on the pig-iron, if the whole of the slag can be so disposed of. The actual saving is more than as stated above, as, unless a market is found for the slag, it has to be carried to some considerable distance from the furnace, causing haulage charges, and in most cases the occupation of land necessitating rent charges.

Another source of economy is the manufacture of:—

Slag Cement and Slag Bricks.—The blast furnace slag from Vizcaya, Spain, is first converted into slag cement, and this is then used as a building material in the manufacture of slag bricks. Three parts of slag are mixed in the dry with one part of lime in powder, the slag having in the first place been granulated. The mixture is then ground to the necessary degrees of fineness. In 12 hours about 20 tons of cement is made by 7 men, 12,000 bricks per day of 10 hours, by 10 men, 1 woman, 2 boys, four parts by volume of dry granulated slag and 1 of cement being employed.*

* Mr. F. Toldt: Proceedings of I & S. I. No. 2, 1893.

4,000 H.P. BLAST FURNACE GAS TREATMENT PLANT. THWAITE-GARDNER SYSTEM.

Granulated blast furnace slag having the following proportions per cent.,—

Silica.	Lime.	Alumina and Oxide of Iron.	Magnesia.	Sulphur.
27·78	51·71	11·70	1·39	1·31

when mixed with water, slacked lime, and subjected to the necessary grinding, has been employed in the manufacture of slag cement.*

Sand made from blast furnace slag used at Stuttgart for public walks, realised, 4*s.* 6*d.* per cubic metre as compared with 7*s.* to 9*s.* for good river sand.† Slag wool is another source of revenue, but this can only account for a small portion of the slag produced.

The following tables of Analyses of Slags, and Substances obtained from them, will be of service in indicating the direction of profitable application to different uses.

* E. C. Eckel, *Engineering News*, Vol. 47.

† Proceedings, Iron and Steel Institute. No. 2, 1891.

Composition of Various Descriptions of Slag.*

	Middlesbrough.	Bilbao.	Saulnes.	Clivindez.	Harzburg.	Belgium.	Glass.
Lime	32·75	47·30	47·20	45·11	48·59	44·75	12·5
Silica	30·00	32·90	31·65	26·88	30 72	32·51	69·0
Alumina	28·00	13·25	17·00	24·12	16·40	13·91	7·4
Protoxide of Iron	0·75	0·46	0·65	0·44	0·03	0 48	—
Magnesia	5·25	1·37	1·36	1·09	1·28	2·20	—
Sulphide of Lime	1·90	3·42	—	1·86	2·16	4·90	—
Manganese	0·60	1·13	0·85	0·50	traces	0·60	—
Residue	0·75	0·17	1·29	—	0·42	0·65	soda 11 1
	100·00	100·00	100·00	100·00	99·60	100·00	100·0

* Gilbert Redgrave, *Iron*, Feb. 14, 1890.

Analysis of Substances obtained from Slag.

	Chilled Slag.	Slag Sand.	Slag Mortar.	Slag Brick.	Slag Cement.	Portland Cement.	Thomas Slag No. 1.	Thomas Slag No. 2.
Lime	29·44	29·76	29·40	22·31	39·68	61·07	41·58	47·34
Silica	36·50	36·56	25·15	21·60	24·34	21·70	7·38	5·76
Alumina	22·95	22·98	21·80	19·85	8·74	8·60	2·57	1·43
Protoxide of Iron	0 06	0·06	1·44	4·00	0·27	—	13·62	12·72
,, Manganese	0·32	0·31	0·26	0·21	0·23	—	3·79	3·43
Peroxide of Iron	—	—	1·66	8·80	0·14	2·25	8·54	2·07
Magnesia	5·94	5·93	5·10	4·36	6·59	1·17	6·14	6·01
Potash	0·59	0·60	0·53	0·50	0·28	0·75	—	—
Soda	0·36	0·33	0·36	0·32	0·44	0·42	—	—
Sulphur	—	—	1·00	1·19	0·93	—	—	—
Sulphuric Acid	—	—	1·25	1·54	0·25	1·93	0·12	trace
Sulphide of Lime	3·89	3·51	—	—	—	—	0·54	0·91
Carbonate of Lime	—	—	—	—	4·07	—	—	—
Phosphoric Acid	—	—	0·01	0·02	—	—	14·36	19·19
Carbonic Acid	—	—	2·60	3·00	—	0·80	—	—
Water, &c.	—	—	9·50	12·00	4·70	1·26	1·29	1·19
	100·05	100·04	100·06	99·70	90·66	99·95	99·93	100·05

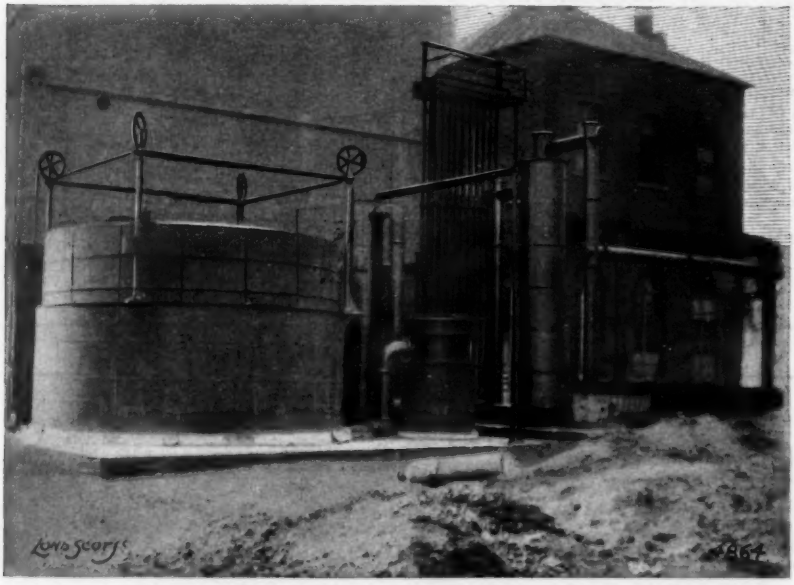
Certain classes of blast-furnace slag can be utilised in the manufacture of Portland cement, of which large quantities are employed in the building of docks, breakwaters, foundations, etc.

The chemical constitution of Portland cement of good setting quality must in its chief elements be within the following limits :—

Lime	CaO	47% to 60%
Silica	SiO_2	20% to 35%
Alumina	Al_2O_3	5% to 15%
Magnesia	MgO less than	3%

blast-furnace slag are now employed in the manufacture of this material, it is necessary for furnace proprietors to have analyses and tests made of the slag, to ascertain whether it is available for application in this direction, as a source of profitable recovery of this by-product.

The suitability of blast-furnace slag for utilisation in the manufacture of Portland cement is at present in the hands of the chemist of the cement works, owing to his being well grounded in the necessity for keeping the deleterious ingredients of the

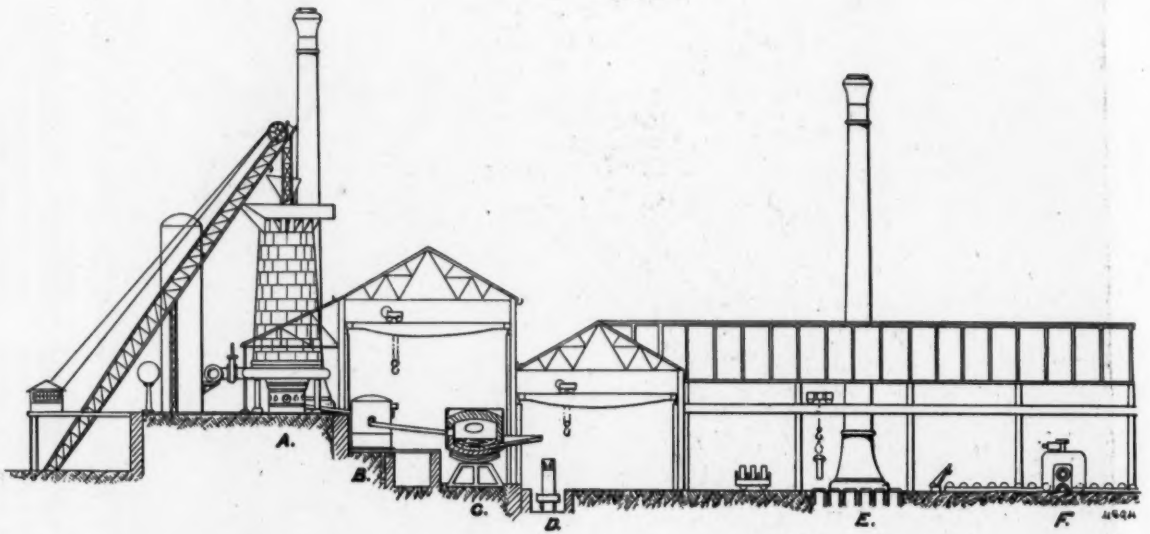


RECOVERY OF COMBUSTIBLE HEAT OF BLAST FURNACE GAS: APPARATUS FOR SEPARATING THE DUST, RENDERING THE GAS SUITABLE FOR GAS ENGINES—THWAITE-GARDNER SYSTEM.

From the above it will be evident that slag containing a higher proportion of magnesia than about 3 per cent. could only be used in admixture with cement clinker to such proportion as would keep the proportion of magnesia below the limit given. The sulphur or sulphuric acid content of the slag should also not be high. As considerable quantities of cement within certain limits; but if ironworks chemists gave a little more attention to this manufacture, it is extremely probable that at many ironworks the profitable application of the slag to this purpose would result in a considerable economy, through the more general application by selection of suitable qualities of slag.

It will be obvious that the greatest

VERTICAL BLOWING ENGINE DRIVEN BY BLAST FURNACE GAS. CLAY CROSS IRONWORKS.



STEVENSON'S SYSTEM OF RUNNING MOLTEN IRON DIRECT FROM THE BLAST FURNACE INTO A STEEL FURNACE, THUS PREVENTING LOSS OF HEAT.

A. Non-Crucible Blast-Furnace. *B*. Luted Receiver. *C*. Steel Furnace. *D*. Casting on Cars. *E*. Vertical Furnaces. *F*. Slabbing Mill.

economy can be derived from any application which will affect the whole of the slag resulting from the manufacture of pig-iron at the furnaces, as, for most of the applications reviewed, only a comparatively small proportion of slag can be thus utilised.

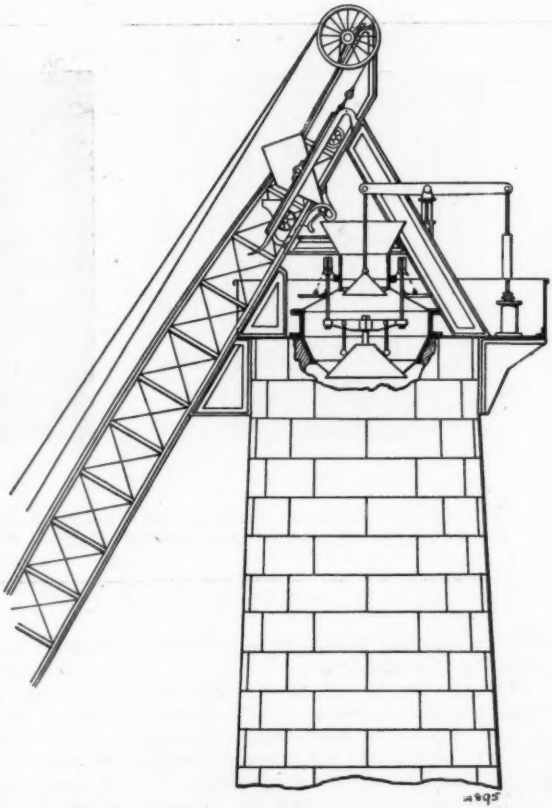
III. *Blast Furnace Gas.*—The smelting of iron in furnaces by means of air blast is accompanied by the evolution of large volumes of gases at the top of the furnace, careful estimates showing that, for each ton of coal consumed in the blast furnace, there would be about 160,000 cub. ft. of gas evolved if measured at atmospheric temperature and pressure, while the volume per ton of coke is about 170,000 cub. ft., measured under the same conditions.

The chief constituent in either case is nitrogen which has a proportion above one half. The bulk of the gaseous mixture consists of inert gas, the remaining portion being chiefly carbonic oxide, with small proportions of hydrogen, marsh gas, etc.

The adjacent table shows characteristic analyses of blast furnace gas.

Sensible Heat.—The gases leaving the top of the furnace are in a more or less highly heated state, carrying off sensible heat equivalent to from 7 per cent. to 10 per cent. of the total heat value.

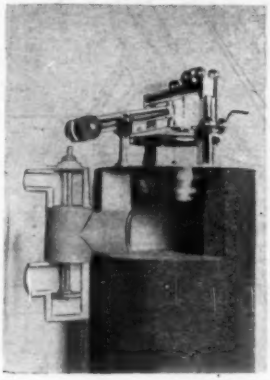
It would be almost, if not quite, impossible to recover the whole of this heat, though where the gases are passed through brick flues or brick-lined tubes, a proportion of this sensible heat is retained by the gases, and assists their combustion



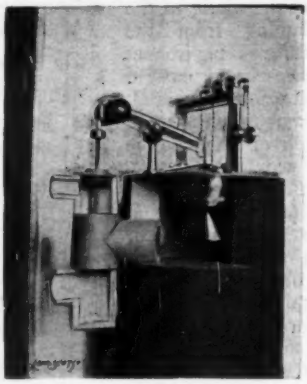
STEVENSON'S BLAST FURNACE CHARGING APPARATUS, FOR EFFECTUALLY DISTRIBUTING THE MATERIAL IN THE FURNACE AND PREVENTING ESCAPE OF GAS WHEN LOWERING THE BELL.

Typical Analyses of Blast Furnace Gas: Per Cent. by Volume.

	Fuel.	Raw Coal.	Coke and Coal.	Coke only.	
Inert.	Nitrogen, N.	60·7	55·0	59·5	56·0
	Carbonic Acid, CO_2...	6·5	5·0	9·0	5·0
Combustible.	Carbonic oxide, CO...	26·0	34·0	30·0	35·0
	Hydrogen, H	4·5	3·5	1·5	2·0
	Marsh Gas, CH_4 ...	2·3	2·5	—	2·0
		100·0	100·0	100·0	100·0



Bell closed—Cover raised.



Bell lowered—Cover down.

CHARGING BELL COVER FOR PREVENTING LOSS OF GAS AT BLAST FURNACES, WITH AUTOMATIC VALVE FOR PREVENTING AIR BEING DRAWN INTO GAS TUBE. THWAITE-GARDNER SYSTEM.

in the stoves and boilers, so that it must not all be considered waste.

However the gas, if taken direct to stoves and boilers without being subject to any process of purification, carries with it a considerable proportion of water vapour, besides dust, and a light fume.

Utilisation of Blast-Furnace Gas.—Previous to the application of blast furnace gas for the development of power direct in gas engines, it was only employed in an uncleansed state for raising steam in boilers and heating the blast.

This method of recovering this by-product, though effecting considerable economy, is only crude; for the dust and fume carried by the gases rapidly encrusts all surfaces into which they come in contact, both before and during combustion, with a highly non-conducting deposit, as far as heat transference is concerned, with the result that the stoves rapidly fall off in efficiency. (See Table of Analyses of Dust in Gases on next page.)

It will be noticed from an examination of the analyses given that the dust in some cases has a high proportion of oxide of iron; in other cases coke-dust, or carbonaceous matter, is present, and zinc oxide is very often present in considerable proportion.

The composition of the dust deposited in the down-comer and flues also varies in regard to the distance from the furnace at which it is deposited.

Close to the furnace the heavier particles are deposited, consisting largely of fine portions of iron ore and coke, the fume being carried along to considerable distances.

Flue dust having a fair proportion of zinc oxide is available for use as a source of zinc recovery, and the dust resulting from the manufacture of ferro-manganese and spiegeleisen generally carries such a proportion of zinc oxide as to be able to bring in a fair price, up to £3 per ton in some cases. When the proportion of oxide of iron is high the dust may be returned to the furnace in the form of briquettes after suitable treatment, the iron content being reduced and the earthy portion acting as flux.

It has been stated that blast-furnace

Analyses of Dust in Blast-Furnace Gases: Percentage Composition.

—	Grey Dust in Main Gas Pipes.	White Dust from Cowper Stoves.	White Dust from Boiler Flues.	From Dust Catchers (Cleveland).	From Flues (Cleveland)	From Stoves and Boilers after Combustion (Cleveland).	Furnace Making Spiegel.	Furnace Making Spiegel.	Cowper Stove Combustion Chamber.	*b*	Dust before Fan (Differdinge).	Dust from Engine Cylinder (Differdinge).
Loss on Calcination	8·40	0·50	3·50	18 5	24 5	23·55	—	64	—	1·19	7·55	7·85
Silica ... ... SiO_2	11 60	21·10	18·40	—	—	—	—	2·41	20·01	26·60	27·76	29·94
Alumina ... ... Al_2O_3	* 5·30	6·70	4 80	10·0	12·15	10·0	—	0·23	7 20	9·17	13·71	13·52
Lime ... ... CaO	4·00	9·50	14·60	8 9	7·2	12·0	—	1·85	17·00	24·40	27 50	24·50
Magnesia ... ... MgO	0·50	2·00	2·35	—	—	—	—	—	·21	—	3·81	2·45
Zinc Oxide ... ... ZnO	3·75	7 75	4·35	12·0	3·8	10·44	50·35	87·66	4·00	—	—	—
Lead Oxide ... ... PbO	3·30	6·90	6·40	—	—	—	—	—	—	—	—	—
Ferric Oxide ... ... Fe_2O_3	39·00	14·70	19·45	—	—	—	—	—	37·43	31·79	—	—
Ferrous Oxide... ... ... FeO	16·30	1·80	0 00	—	—	—	—	1·27	—	—	8·93	5·12
Manganous oxide .. ... MnO	0·50	1·50	1·60	—	—	—	—	3·60	1·50	1·44	4·90	5·93
Sulphur ... ... S	1·05	0 75	0·15	—	—	—	SO_3	0·49	9·27	Trace	—	—
Alkalis, soluble in water	0·20	7·20	7·50	}								
Alkalis, insoluble in water, and sulphates with a few chlorates ...	5·80	18·90	16·90	} —	—	13·44	—	—	4·28	5·73	—	—
Insoluble matter	—	—	—	18·2	20·2	14·3	—	—	—	—	—	—
Moisture	—	—	—	—	—	—	9·68	—	—	—	—	—
Phosphoric acid ... ... P_2O_5	—	—	—	—	—	—	—	0·70	·05	0·07	1·266	1·186
	99·70	99·30	100·00	—	—	—	—	—	100·95	100·39	—	—
	*	*	*	†	†	†					‡	‡
Iron as oxide ... ... Fe	40 0	11·7	13·6	20·1	19·9	5 95	—	1·0	26·2	22·2	—	—

* Seraing, Mr. Bryan Donkin: *Proceedings Inst.C.E.* † Mr. Wright: *Proceedings Inst.C.E.* ‡ *Iron & Coal Trades' Review*, Feb. 13th, 1903.

gas consists of a mixture of inert and combustible gases, so that, besides the sensible heat carried away from the furnace by the bulk of the gas, the combustible heat constitutes a very much more valuable by-product. Each cubic foot of gas is capable of giving out about 100 B.T.U. on combustion. As coke is capable of developing on complete combustion 13,000 B.T.U. per lb., 2,240 + 13,000 = 29,120,000 B.T.U. per ton. The gas evolved from the combustion of a ton of coke in the furnace being 170,000 cub. ft., this at 100 B.T.U. = 170,000 × 100 = 17,000,000 B.T.U., or 58 per cent. of the thermal value of the coke consumed.

The earliest attempt to recover this valuable by-product was its application in its more or less crude state to combustion for raising steam and heating the blast stoves. (See illustration).

However, the methods adopted were far from perfect, as the efficiency was largely dependent upon the results to be obtained from chimney draught, associated as it is with constantly varying atmospheric conditions. As the dust carried along with the gas was not separated to any considerable extent or the water vapour removed, the result could only reach a low efficiency.

The application of blast-furnace gas to develop power in gas engines has been found a great advance in the effective recovery of the combustible heat; and this source of profitable application is making rapid strides, more especially where the gas has been freed from dust and moisture in an effective manner.

This subject was fully dealt with in the first number of this Magazine, and since then numerous results of the running of large gas-engine installations by blast-furnace gas have appeared in the engineering papers. (See illustrations.)

Where raw coal forms the fuel, either in whole or in part, as the splint coal of Scotland, or the part use of raw coal mixed with coke as in Derbyshire, Staffordshire, etc., though the furnace has to combine the work of the coke oven with that of smelting, there are points of economy which should be kept in view.

Though the volatile matter given off from coal in the blast-furnace does not have any part in the reduction of the iron ore, the loss of fuel which takes place in the coke oven is prevented to a large extent.

Coal when coked in ovens is discharged at a high temperature and has to be quenched with water. The sensible heat alone amounts to about 3 per cent. of the total heat of the fuel, while the water used for quenching being largely turned to steam, and the remainder, after the coke is cold, amounting to from 2 per cent. up to 16 per cent. in some cases, has to be evaporated in the blast furnace.

Other by-products become recoverable when raw coal is the fuel used, as for instance tar, ammonia, etc. Mr. Hamilton* estimates the yield of anhydrous tar, in Scotland in the year 1900, to be 122,000 tons.

The recovery of tar, ammonia, and oil is practised at nearly, if not quite, all the ironworks in Scotland, the production in 1901 being on the average as follows:—

Per Ton of Coal.†				
Sulphate of ammonia	...	...	...	22·67 lbs.
Pitch	...	...	...	119·8 ,,
Oil ..	...	..	...	7·3 gals.

The average market value of sulphate of ammonia is about £12 10*s.* per ton, so that 22·67 lbs. would be worth 2*s.* 6*d.*

The *rationale* of the method employed for the treatment of the blast-furnace gases for the recovery of the above by-products is worthy of a special article, and those interested would do well to study Mr. Hamilton's paper, as results obtained in different localities other than in Scotland are not always those expected. In Derbyshire, where a mixture of native coal is used with coke in the blast furnaces, some of the gases are applied for driving gas engines; and it is found that, with a 120-h.p. gas-engine continually running, as much as 40 gallons of tar are recovered by the gas-cleaning plant per diem.

Besides the tar there are certain oils, as stated, which are recovered by the same apparatus as is employed for recovering the ammonia and tar. Even though the

* Notes on the "Recovery of By-Products from Blast Furnace Gases," by R. Hamilton, West of Scotland Iron and Steel Institute.

† International Congress, Glasgow, 1901.

apparatus necessary for treating blast-furnace gas for recovering the by-products, owing chiefly to the enormous volumes of gas to be dealt with, necessitates a considerable first cost, it is found to be a source of considerable economy from a commercial point of view; and the gas, after passing through the process, is still available for further application to recover its combustible heat; for at Wishaw, in Scotland, the first application of this gas for developing power in gas engines was made with gases which had been treated for ammonia and tar recovery, by Mr. B H. Thwaite in 1894.

In Great Britain a number of large gas engines are being driven by blast-furnace gas, while in Belgium and Luxemburg this method of heat recovery has been taken advantage of to a considerable extent. M. Brügmann* says, in regard to this method of advanced economy, "Neither the existing technical defects, nor the question of cost will, however, prevent the adoption both of blast-furnace gas-engines, and of ordinary gas-engines, as is evident from the rapidly extending use of these. It may rather be assumed that the employment of such machines is still only in the initial stage."

In regard to the cleaning of blast-furnace gas for use in gas-engines, there has been considerable misapprehension as to the requirements. A study of the series of articles which have been appearing in the *Iron and Coal Trades' Review*, and the report of the experiments carried out by Messrs. Cochrane & Co., of Middlesbrough, indicate that the main idea was to free the gas from the more or less heavy particles of dust by means of fans only. In all cases this has been found unsatisfactory, owing to the fact that it is the fine impalpable fume carried by the gas which causes accumulation both in steam boilers and the combustion chambers, and passages, of gas-engines. This brings about inefficiency in boilers, and necessitates the pulling to pieces and cleaning of the combustion chambers and valves of gas engines. It is an established fact that the treatment of blast-furnace gas for gas-engines should include the following:—

1. Cooling.
2. Coarse filtering.
3. Fine filtering and removal of the moisture.

The removal of the fine impalpable fume is the most important, as the cooling is chiefly necessary to allow of the gas being propelled by means of fans through the cooling and filtering apparatus, and it stands to reason that if the gas will carry and deposit fume, not only in the tubes of boilers, but even out of the top of high chimney stacks, that, unless this is removed, it will cause accumulations on the interior of the combustion chamber, and about the valves of gas engines. Though the coarse dust might enter the combustion chamber and be carried forward by the expansion of the exhaust, the fume deposit on the surfaces with which it comes in contact would soon reach a sufficient thickness to cause premature ignition through its becoming incandescent.

Though the subject cannot be considered as exhaustively treated, it has been shown that very considerable economy has already been effected due to the advance in chemical and technical application brought about by keen competition.

* Iron and Steel Institute, Sept. 1902.

Coal Cutting by Machinery.

By J. W. CHUBB, A.M.I.E.E.

THE probable duration of the coal supply of Great Britain has formed the subject of the calculations of mathematicians and others from the time, say of Lardner—to go back no further—up through Jevons to the latest engineering professor. The results of these calculations have of late years generally been of a pessimistic character. Lardner, however, in 1851 wrote as follows: "The enormous consumption of coals produced by the application of the steam-engine . . . . has of late years excited the fears of many as to the possibility of the exhaustion of our coal-mines. Such apprehensions are, however, altogether groundless. If the present consumption of coal be estimated at sixteen millions of tons annually, it is demonstrable that the coalfields of this country would not be exhausted for many centuries." The insufficiency of the grounds of this estimate will be obvious if we state that the total production of coal in Great Britain, even in 1900, amounted to more than 225,000,000 tons, while the output of the United States of America exceeded 240,000,000 tons, the figures for Great Britain for 1901 and 1902 being about 219,000,000 and 227,000,000 tons respectively. With these enormous quantities of material to be treated it will, of course, be thought that mechanical methods are readily employed; and indeed for hauling, pumping, etc., this is the case. For the actual winning of the coal, however, manual labour predominates both here and in America. Thus it is estimated that about three-quarters of the American coal is got by hand, while in England the most optimistic estimate of machine-cut coal does not place its proportion of the total production higher than 2 per cent. Relatively to Great Britain, therefore, America makes more than twelve times the use of mechanical coal-cutters, the number of these in employment now considerably exceeding 4,000. It is doubtless in some measure due to this fact that the coal production in the United States has increased with such speed as to overtake that of our own country. The reluctance of colliery-owners to put down coal-cutting plant has been ascribed to many causes, and the one that has come readiest to the pen has ever been the opposition of the working collier, who undoubtedly generally thinks he foresees in the introduction of the "iron man," lessening of wages and of opportunities for employment. But the real advantages of cheapened production, with, as a consequence, increase of demand, should appeal to capitalists more potently than appears to be the case. It is indeed a fact that some colliery-managers doubt the advantage of the machines, a few actually asserting that there is no material saving when coal-cutters are used. Much, it must be admitted, depends on the men in charge of the machine, and success is generally quite assured when, as is the practice of most manufacturers, a working collier is taught whatever is necessary to control and run the machine. Probably the working efficiency would be highest were a collier associated with a skilled engineering machanic, the practice thus being followed of some printing-machine manufacturers, who make sure that, in conjunction with their own trained engineers, a skilled printer shall be employed in the management of the printing machinery they supply. Further, as in all production businesses, the full advantage of the machinery can result only when the closest possible approximation to continuous running is obtained, and for this, it is unnecessary to add, the time occupied in moving, fixing, setting the timber, laying the rails, and preparing the road, and the working face of the coal must be

kept as low as possible. Again, it is not to every colliery that mechanical coal-cutters can be applied successfully, but makers of the machines are generally willing, before taking an order, to examine the conditions, and, if advisable, to guarantee results and even to undertake the cutting at a fixed price. One aspect of the case deserves a little attention, namely, that it is sometimes profitable to work by machinery seams that would not be worth the attention of hand labour. Thus it has been asserted that, in addition to the gain derived from the decreased cost of winning the coal, there is a saving in the reduction of the slack, and as much as 14 per cent. advantage has been claimed, the depth of holding in the case of a machine being 4 ins. or 5 ins. according to the form of the cutters, whereas on hand-hewn seams the depth may be 8 ins. or more.

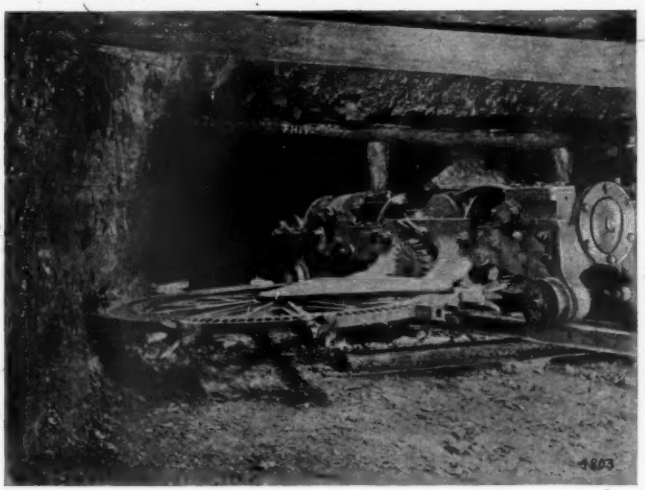


FIG. 1.—COMPRESSED-AIR MACHINE CUTTING IN.

And here it may be worth noting why American coal-cutters, when introduced into this country, have not met with the

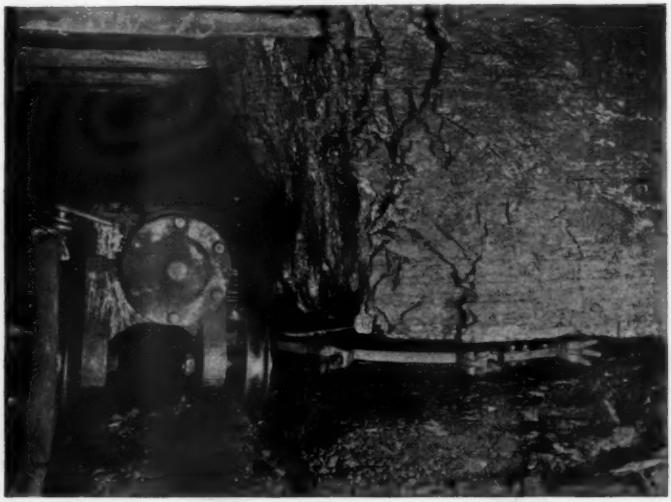


FIG. 2.—MACHINE UNDERCUTTING FULL DEPTH.

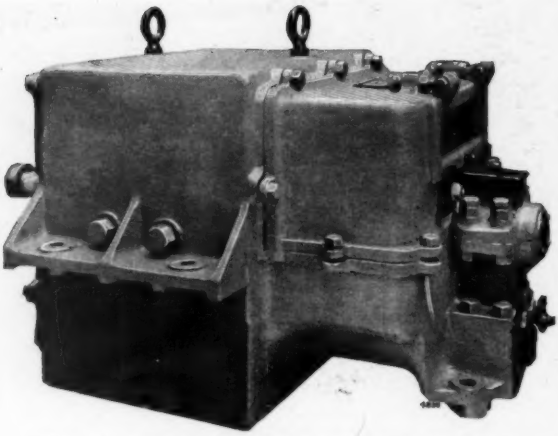


FIG. 3.—COAL-CUTTER MOTOR BY MESSRS. ERNEST SCOTT AND MOUNTAIN.

success that was anticipated for them. In America the coal seams are often thick, while here thinner seams, more difficult to work, have now to be mined. The under-cutting has consequently to be done in hard stone or tough fire-clay; thus in a list of 70 machines supplied by one English firm no less than 64 are specified as "cutting hard fire-clay." This method is used to avoid waste of coal, and American machines have before now failed in the work when tested under British conditions, whereas for the American seams of a thick, easily-worked character, they were doubtless quite well adapted. Thus, while here disc machines are most used, in America chain machines and percussion drills are generally employed.

Necessarily, when mechanical coal-cutters are introduced, the method of managing the mine must often undergo modification. Thus the timbering must be suited to the machines, and further the rails on which the coal-cutters run when at work must form a solid road to take not only the weight of the machine but also the thrust of the cutters. A flat-bottomed rail, weighing 26 lbs. to the yard, and sleepers 4 ft. 6 ins. apart have been advocated. Further, arrangement must be made for working the machine into the seam to the cutting depth; this will be referred to later, but meanwhile Figs. 1 and 2 will illustrate the point, the first showing the machine, compressed-air driven, just cutting its way in, while Fig. 2 illustrates a similar machine working the full undercut.

The history of the mechanical coal-cutter goes back to 1761, the first inventor

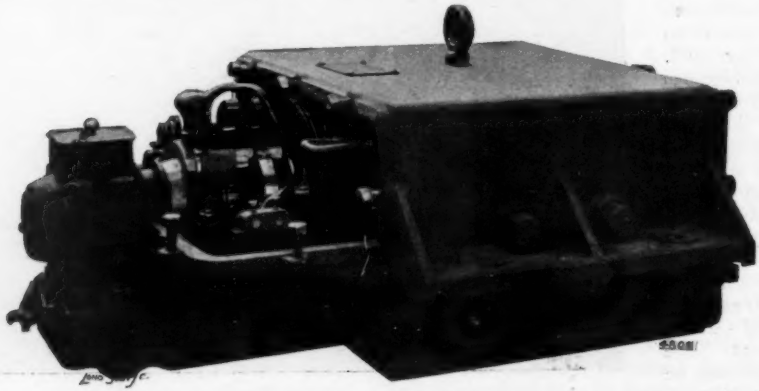


FIG. 4.—ENCLOSED MOTOR BY MESSRS. ERNEST SCOTT AND MOUNTAIN—PART OF CASING REMOVED.

being, probably, Michael Menzies, of Newcastle. But of really practicable machines, one of the earliest was made about 100 years later. This was Firth's pick machine, the action of which was based on that of a miner at work. An improved machine was brought out by Firth & Donnisthorpe in 1870. Essentially the appliance consisted of a bell-crank lever, one arm of which was driven by a horizontal engine while the other held the cutter. The writer is not certain of the existence of such a machine now, but some ten years ago had particulars of a Firth machine in use at a colliery near Leeds, where the width of holing at the bottom of the cut was about 2 ins., the machine on trial undercutting to a depth of 3 ft. 9 ins. for a length of 28 ft., in less than an hour. Two cuts were taken, one with a light pick to a depth of 2 ft., whereas the remainder was cut with a 90-lb. pick making 60 blows per minute. The object, not peculiar to this machine, however, was to imitate the action of a miner, as has been stated. These attempted reproductions of human actions are, as a rule, seldom successful, a notable exception being the distributing device of the Linotype machine. Of the forms of coal-cutter in use the principal are the chain, bar, and disc types, and the two first of these were introduced about 1853 and 1856 respectively. Probably the earliest disc machine was made in 1870 by Winstanley & Barker,

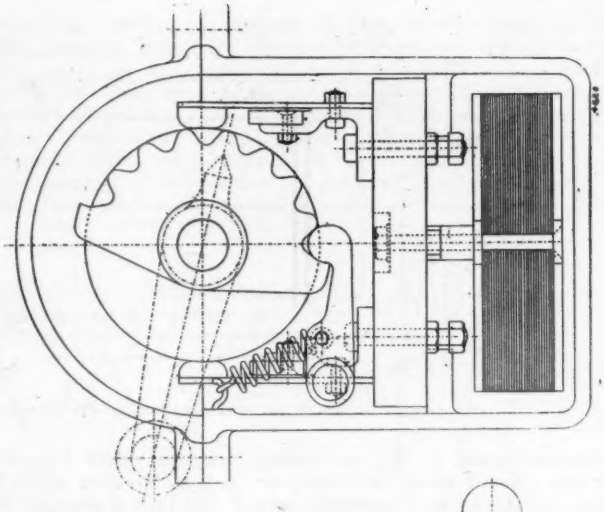


FIG. 6.—WORKING DRAWING OF CONTROLLER FOR COAL-CUTTER MOTOR.

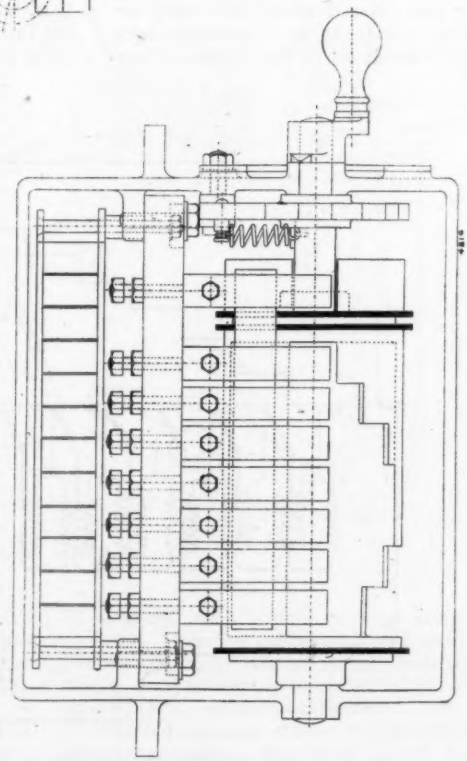


FIG. 5.—WORKING DRAWING OF CONTROLLER FOR COAL-CUTTER MOTOR.

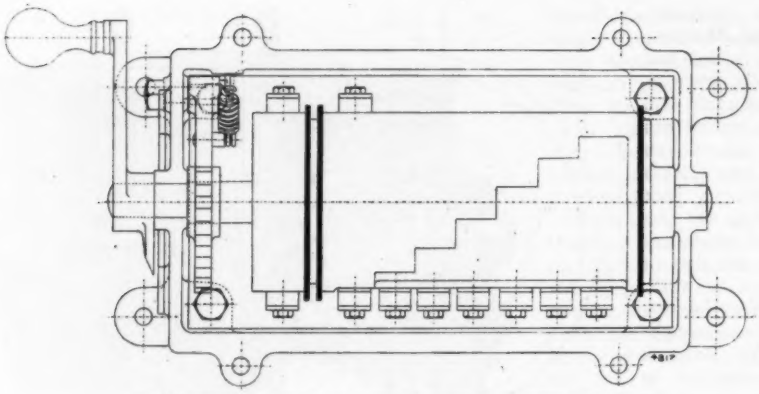


FIG. 7.—WORKING DRAWING OF CONTROLLER FOR COAL-CUTTER MOTOR.

of Manchester, and in this the cutting wheel was centred on an arm that, for entering, moved out to a position at right angles to the length of the machine, where it was locked for cutting the full depth. It is, however, hardly worth while spending further time on the consideration of these old forms of machines.

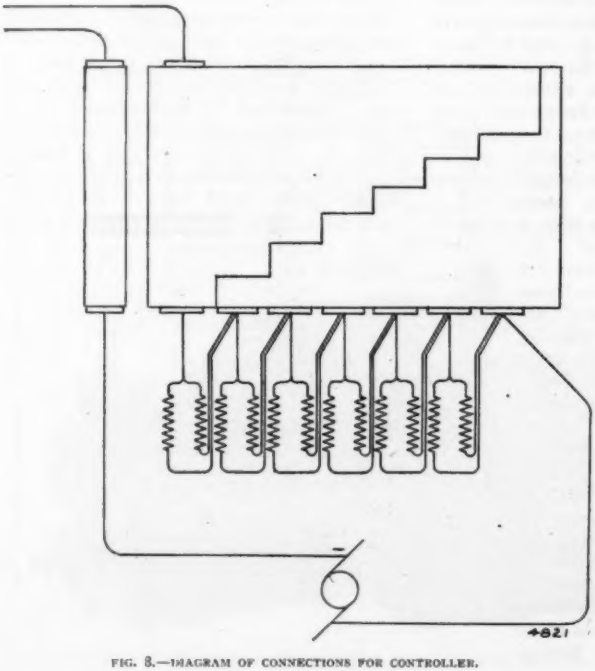


FIG. 8.—DIAGRAM OF CONNECTIONS FOR CONTROLLER.

Coal-cutters are now generally driven either by electric motors or by compressed-air motors. Hydraulic machines have been employed, it is true, as, for instance, in the case of the Carrett & Marshall machine. This is notable for its action, which is that of a plane with three cutters, making a stroke of, say, 4 ft. about 15 times a minute. Into the comparative merits of electricity and compressed air it is not the intention here to enter; in fact, to the supporters of both it is evident that—"there's nothing like leather." Still it will generally be conceded that electric coal-cutters are lower in first cost and in maintenance charges, besides being more

efficient than compressed-air motors, especially with working faces at long distances from the shaft.

The voltage is generally from 500 to 600, the current being continuous or direct. Polyphase working, despite its freedom from sparking, is seldom attempted; in fact, the writer believes that the Diamond Coal-cutter Co., of Wakefield, are the only British makers of machines with poly-phase motors. It will, therefore, be convenient to say at once that the company just mentioned inserted in their earlier machines, for starting, a loose clutch in the gearing, to allow about 15 revolutions start for the motor. Later machines have slip-rings in place of the clutch, but excessive current is generally needed by this type of motor, which, indeed, possesses hardly any advantages over the continuous- or direct-current machine. The motors are, of course, generally totally enclosed, although it is very difficult to make them quite gas-tight. Further, it is certainly advisable to enclose all switch boxes; and, if possible, fuses should be kept above ground. Defective cables are also a ready source of breakdown in mining installations, and uniformity of practice as to insulation in employment is still to seek Vulcanised bitumen cables can generally be recommended, and they should be

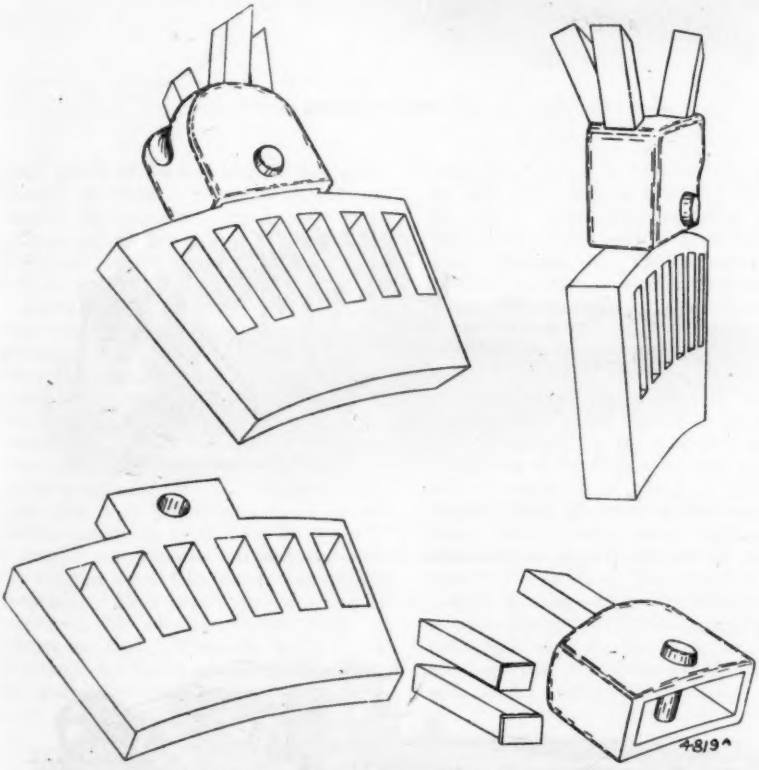


FIG. 10.—DETAILS OF "DIAMOND" CUTTER BOX.

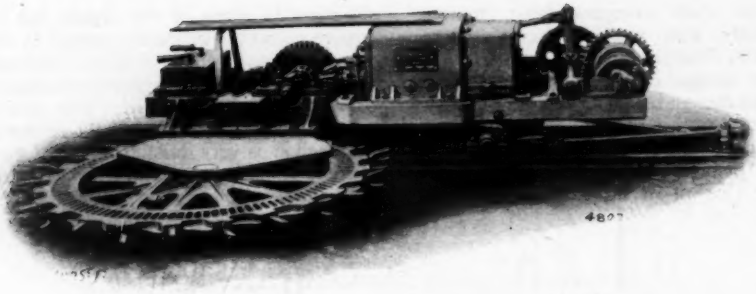


FIG. 9.—CLARKE COAL-CUTTER.

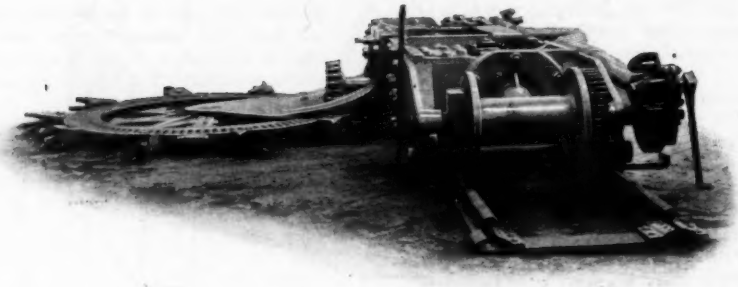


FIG. 11.—"DIAMOND" COMPRESSED-AIR COAL-CUTTER FOR THIN SEAMS.

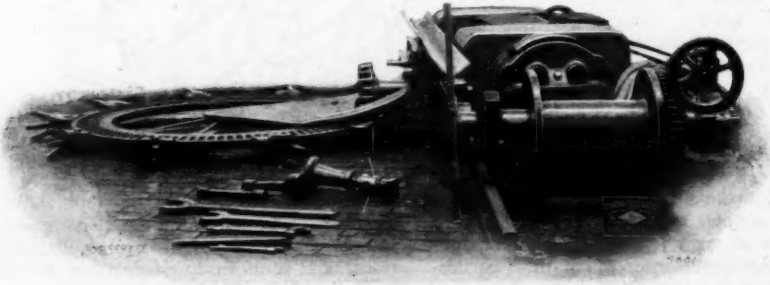


FIG. 12.—"DIAMOND" ELECTRIC COAL-CUTTER FOR THIN SEAMS.

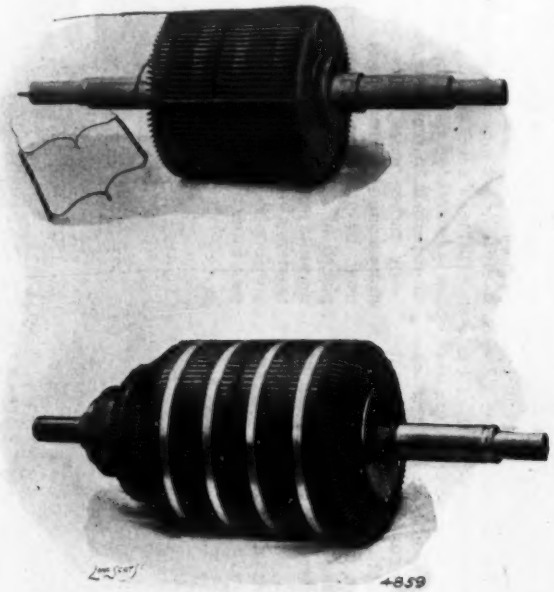
FIG. 13.—COMPRESSED-AIR COAL-CUTTER WORKING AT HEIGHT ABOVE FLOOR.

given plenty of slack to prevent stretching caused by falls. Sometimes they are carried on porcelain insulators, or in grooves cut in the side of the coal; but if they are buried under the floor falls of coal are hardly likely to injure them.

There are even now some mine managers who object to use electric motors in the presence of gas; yet it would be hard to learn of a case where the gas was ignited electrically by accident. Still it has been proved that at least one motor of an enclosed type will fire an explosive mixture when placed in it for the purposes of the experiment; and there are engineers who hold that it is possible to cause an explosion simply by contact of the gas with a heated commutator. However, it is the rule to have the motors completely enclosed. Thus the type of machine employed by Messrs. Ernest Scott & Mountain, Ltd., Newcastle-on-Tyne, is illustrated by Fig. 3, which shows clearly the inspection window for the commutator, brushes, etc. Another motor made by the same firm is similarly illustrated by Fig. 4. This time, however, part of the casing is removed to show the brush gear, armature, etc. The substantial character of the design, rendered necessary by the rough usage to which the machines are subjected, will be evident from these illustrations. The Scott-Mountain machines, it may be added, are series-wound, and are made both two-pole and four-pole magnetically. The speed is about 900 revolutions per minute, and each machine is capable of developing 23 h.p. normally, but will work up to 40 h.p. or 50 h.p. for short periods. Gramme-wound armatures, being rather more easily repaired than drum-wound armatures, were at one time used by this firm, the winding being placed in slots, which were insulated with micanite troughs. With the newer low-type machines made by the firm the motors are four-pole, and have drum armatures with former-wound coils in slots.

FIG. 14.—ELECTRIC COAL-CUTTER WORKING AT HEIGHT ABOVE FLOOR.

ARMATURE BEFORE BEING WOUND.



ARMATURE COMPLETE.

FIG. 15.—ARMATURE OF MOTOR FOR COAL-CUTTING MACHINE
BY T. HARDING CHURTON AND CO.

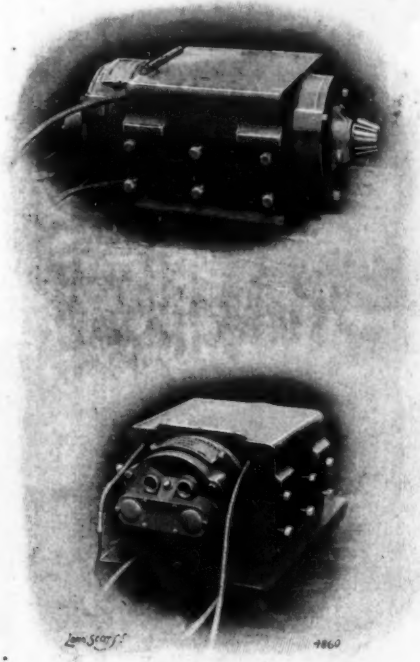


FIG. 16.—MOTOR FOR COAL-CUTTING MACHINERY
BY T. HARDING CHURTON AND CO.

For starting and stopping each of these machines a multiple-contact switch with resistance, placed in a gas-tight cast-iron case, was used. Messrs. Scott & Mountain have recently introduced a controller which has been used with success on their latest machines, and of which detail drawings are given in Figs. 5 to 7. The casing is in section, the whole of the internal parts being in elevation. A diagram showing how the connections are varied is given in Fig. 8.

The Scott-Mountain disc machine (Standard type) is illustrated in Fig. 9. The motor casing (just to the right of the illustration), the cutter frame, gearing, and cutter wheel are all of cast steel. This machine is 2 ft. 2 ins. high, measuring from the rail to the top of the casing; but in the special low-pattern machine the height is reduced to 1 ft. 5 ins. The cutter wheels undercut from 3 ft. 6 ins. to 5 ft. 6 ins., the discs used being from 4 ft. to 6 ft. in diameter. They are driven by means of gearing arranged as follows: A bevel pinion, with 14 teeth (4-in. face, 1½-in. pitch) on the armature shaft of the motor, drives a bevel wheel with 36 teeth on the cross or first-motion shaft. On this a spur pinion of 12 teeth (3½-in. face, 1⅜-in. pitch) gears into a spur wheel on the horizontal shaft that drives the cutter-wheel. This, to undercut 4 ft. 6 ins., runs at a peripheral speed of 366 ft. a minute. The decrease in the sizes of the teeth with decrease of speed seems a little unusual. Turning to the other end of the machine, the feed gear consists of a crank driving a rocking lever by means of a connecting-rod. A pawl on the lever engages with a ratchet wheel, which again turns a barrel, on which is gradually wound the wire rope used for drawing along the machine. The rope is attached to the bridle of the machine, and, after passing along the face, is taken round a pulley fastened to the timbers and back to the revolving barrel. The cut advances at the rate of from 8 ins. to 2 ft. a minute, according to the nature of the material; but the feed may rise to 3 ft. a minute in soft stuff, when, the motor being series-wound, its speed will increase correspondingly. This machine known also as Clarke's Coal-Cutter, is made, as regards the mechanical part, by Messrs. Clarke, Steavenson & Co., Ltd., Hoyland Common, Barnsley, and was first introduced ten years ago in the Lidgett Colliery.

The cutters in the Clarke machine are alternately of the straight and forked type, and are secured to the disc by cotter bolts and nuts. In the "Diamond" coal-cutter, however, the wheel (in segments) has bolted to it ten removable boxes, each containing three reversible cutters. The device, with the tools, is shown so plainly in Fig. 10 that description is unnecessary.

In Figs. 11 to 14, some illustrations are given of the "Diamond" coal-cutter, supplied by the firm of the same name at Stennard Works, Wakefield. This firm, who are probably the largest makers of disc machines in Great Britain, were the first to introduce deep undercutting—say 5 ft. 6 ins. or more. Here, however, the demand is for a machine to deal with thinner seams, but it is worth noting that this British firm has licensees in Germany who are manufacturing machines for abroad. Thus this machine was introduced into the Dorstfeld Collieries, only after long enquiries into the merits of mechanical coal-cutters, both British and American. A feature is the use of two air-cylinders, one at each end of the machine, rather than side by side, as is more usual. This decreases the width, a point of no small importance in underground machinery. Further, following the same practice with electric motors, the potential across each is halved, the two machines being in series, and risk of electrical breakdown is reduced, the speed of the armature also being minimised. The motors are each of 10 h.p., but, of course, are capable of taking considerable overloads for short periods. They are boxed in and gastight, and are specially manufactured by Messrs. T. Harding Churton & Co., Leeds (see Figs. 15 and 16).

The motor cases, which are of cast-steel, form the magnet frame-work, and are provided with four poles. The armatures are of the slotted drum-wound type, with former-wound coils, which are separately insulated, and placed in the slots, the latter being strongly lined with mica and

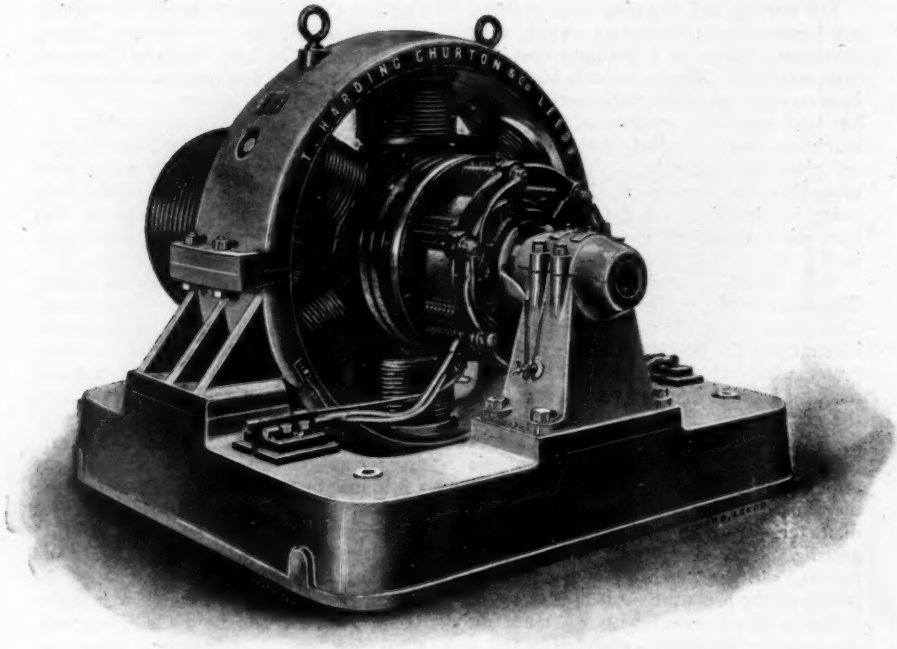


FIG 17.—TYPE OF GENERATOR AS USED IN COLLIERY WORK BY T. HARDING CHURTON AND CO., LEEDS.

presspahn. Owing to the great amount of vibration, and to the severe shocks to which the motors are subjected, the method of insulating and driving the armature conductors is obviously an important matter. Lubrication of the bearings is another item that requires careful consideration, and is, in these motors, satisfactorily effected by oiling rings. Carbon brushes are, of course, employed, and sight-holes in the ends of tthe motors enable the brushes and commutators to be seen through the glass while the motors are running.

Recently, for the purposes of experiment, one of these motors was run a number of trials at full load in an explosive atmosphere, the current being switched on and off, and the machine started at full load. In no case did an explosion result.

The controllers for these machines, as made by Messrs. Churton & Co., resemble the type usually employed on electric tramcars, and are particularly strong. All parts which are liable to wear, or which may be hurt by rough or careless usage, are so arranged that they may be very readily replaced by interchangeable spares. Thus the resistance coils, which may be damaged by the controller switch being left in an intermediate position, are wound on incombustible cylinders, which may be readily replaced, and the contact pieces of the switch may be similarly replaced when required. Following their usual practice, Messrs. Churton & Co. manufacture the motors on the interchangeable system, an advantage which will be appreciated by all mining engineers who have experienced the amount of time and trouble that may be saved thereby.

Turning to the purely mechanical part of the machine, it will be noted that the stiff steel frame carries on one side a steel bracket or butterfly, to which the cutting wheel is pivoted. In the electric machines each motor drives by bevel gearing on to an intermediate shaft, from which, by bevel gearing, the disc is actuated. A driving winch, worked by a rachet device as usual, is placed at one end of the machine. Three of these coal-cutters were supplied to the Middleton Colliery, near Leeds, to undercut 5 ft. 6 ins., the thickness of the cut, in very hard fireclay, being 8 ins. to 10 ins., and more. The actual speed of cutting is 9 yds. or 10 yds. an hour, but the time taken in clearing the cutter-wheel, etc., reduces the actual work to about 50 yds. a shift of 8 hrs. The two series motors on each machine take normally about 50 amps. at 300 volts, and run at about 700 revolutions per minute; they are connected in series. Ordinary rubber cables of good quality are used for following the machines, and are additionally protected by rubber tubing. Spirally-armoured concentric cables were tried, but the armouring wire was sometimes found to be driven through the insulation by falls of the roof. Gas-tight cast-iron boxes, containing double-pole switches and fuses are provided for the gate-ends, which are about 40 yds. apart, and only one coal-cutting machine is connected to a gate-end box at one time. Then when the material increases much in hardness, and thus requires to be cut at a slower speed, or, as more frequently happens, the cutter-wheel is fouled by *débris*, the fuse in the gate-end box is blown by the excessive current taken by the machine, but with careful following the fuses are seldom blown. In the main roads, it is stated, concentric cables armoured with steel wire, are supported with spun-yarn from the timbers every 2 yds. Falls of coal carry down the cable and simply bury it, and no damage has ever been due to this cause—though falls have been frequent.

The standard electrical pressures for these machines, are 260 volts and 500 volts, while for air-motors 45 lbs. to 60 lbs. per sq. in. may be used, the pipes being not less than 2½ ins. in diameter for a single machine, where the length does not exceed 200 yds. Receivers and traps are needed as usual. A feature of the machine is that the disc can be set to cut at various heights, according to the position of the parting. Thus the cutters will work at floor level (see Figs. 11 and 12), or above it (see Figs. 13 and 14), as may be more convenient, a height of 4 ins. being perhaps best, as the dirt can then easily be kept clear of the cut. When working, the machine commences from a heading, and runs into one at the end of the cut, and to prevent hand cutting for starting, a special screw frame is laid on the floor and spragged. On this the machine is placed, and is started with the hauling rope tight and the feed off, the disc cutting its way into the coal by a rachet device that may be worked automatically or by hand.

To convey an idea of the work that can be done by these machines the following

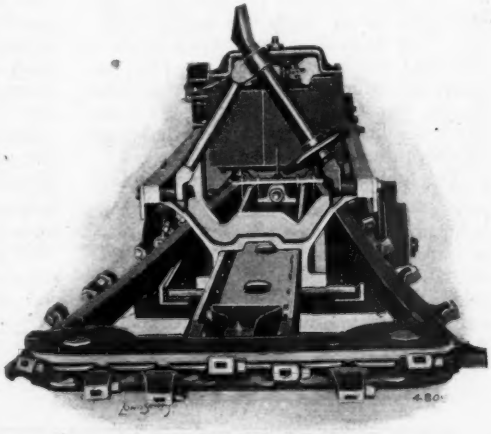


FIG. 18.—MORGAN-GARDNER CHAIN CUTTER, SHOWING CUTTER HEAD.

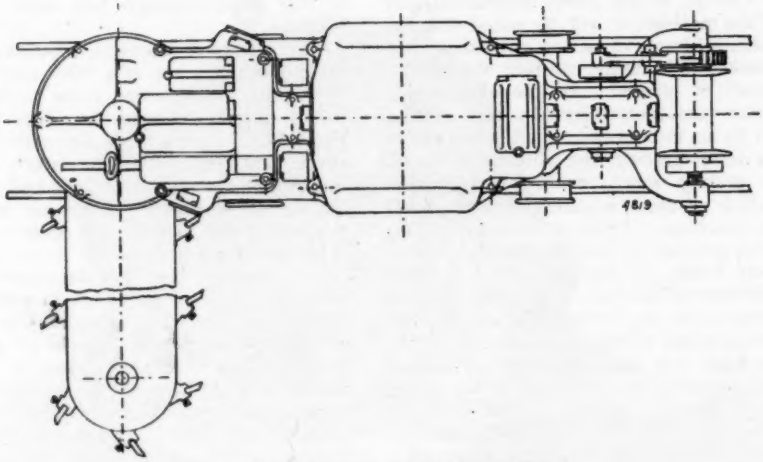


FIG. 19.—PLAN OF MATHER AND PLATT'S CHAIN CUTTER.

quotation may be made. At one colliery, in Durham, several of the "Diamond" coal-cutters, holing in one seam to a depth of 5 ft. 6 ins., in a clean stone band about 2 ft. from the floor, maintain an average run of more than 120 lineal yds. per shift of 8 hrs. At another colliery, near Wakefield, the average for more than 3½ years per machine is 83 yds. per shift, 5 ft. 6 ins. deep, the holing being in a very stiff fireclay. At a small colliery near Leeds a Standard machine working in a 1 ft. 6in. seam has reduced the getting price from 6*s.* 6*d.* per ton by hand to 2*s.* 6*d.* by machine, the output being increased from 18 cwt. to nearly 4 tons per man.

The principal remaining forms of rotary coal-cutter are the bar and chain types. Electrically-operated drills or augers are also employed to some extent. In the bar type the motor drives through gearing a rod bearing a number of cutting tools, and rotating on its own axis, a coupling making the necessary connection between the motor and bar. In starting, the bar may be parallel to the coal face, and, the machine frame being fixed and the cutters revolving, the tools may be gradually worked into the coal as the rod is given a quarter-turn in a horizontal plane. In this position it may be fixed, and the machine can then be set to cut a groove the whole length of the coal face. With this form of cutter falls of coal are not

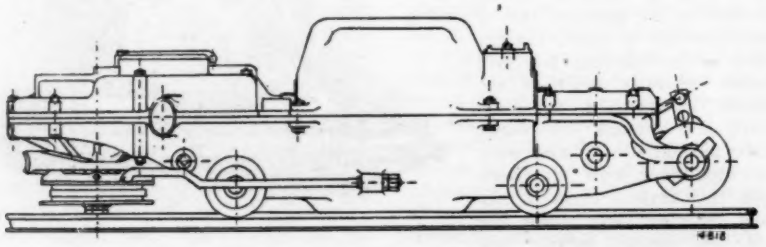


FIG. 20.—SIDE ELEVATION OF MATHER AND PLATT'S CHAIN CUTTER.

serious, as the bar can be uncoupled easily and dug out after the frame has been removed. Thus while with an undulating floor a disc machine might jamb, the bar-cutter is never dealing with a mass of coal more than 4 ins. or 5 ins. in diameter, and as long as the tool bar.

The chain coal-cutter is, perhaps, more at home in America than in England, and it often takes the form of a stationary frame, with which is a carriage, motor-driven, and having a triangular frame around which travels an endless chain bearing the cutters. This chain runs on rollers pivoted at the corners of the triangle, and its base faces the coal, at its apex being the motor. The machine when in position is levelled and jacked or braced, and then the chain is set in motion, the triangular frame feeding bodily into the coal. Thus a slot is made at or about floor-level, the cut being 3 ft. to 3 ft. 6 ins. wide by 5 ft. to 7 ft. 6 ins. deep and, say, 4 ins. or 5 ins. high. An end-view of such a machine (the Morgan-Gardner) is given in Fig. 18, which clearly shows the cutter head. This machine is peculiar in having a vertical armature shaft for the motor, and some of the bevel gearing usually needed is thus avoided. The chain runs at about 270 ft. a minute, and for a 6-ft. undercut bears 48 cutters; these, although all straight and of the same length, are staggered, so that each may take its share of the work. The Morgan-Gardner machine is supplied with trucks for moving about the mine, and also with trunnions for wheels, but without the trucks. The motors run at about 750 revolutions a minute, and undercut the full depth in $3\frac{1}{2}$ mins. to $4\frac{1}{2}$ mins., the return being made in $\frac{1}{2}$ min. to $\frac{3}{4}$ min. A somewhat similar machine, also of American origin but supplied by Messrs. J. Davis & Son, Derby, has already been illustrated in this magazine, and, as regards results, has undercut at floor-level to a depth of 6 ft. in $3\frac{3}{4}$ mins., the power consumed when cutting being 15·4 h.p., and when backing out 2·8 h.p. The height of the cut was $4\frac{1}{2}$ ins. and the width 3 ft. 8 ins., the contents of the undercut at each run consequently being $8\frac{1}{4}$ cub. ft. The cut was made in fairly hard coal, the time taken being $3\frac{3}{4}$ mins., and the number of cutters on the chain was 45. Further, the time occupied in putting the machine into the heading, shifting it across the face three times, and drawing it out ready for blowing down the coal, was 40 mins., two men being needed per shift.

It is obvious that chain coal-cutters make a slot in the coal of practically uniform depth, whereas in several respects a wedge-shaped opening would be better, and for this a percussion drill is well adapted. A straight pick is driven backwards and forwards by an air motor, and, being comparatively small and light (the weight is from 500 lbs. upwards), the machine can easily be adjusted as to position, rate of striking, and force of blow. Thus the Ingersoll-Sergeant pick machine can, with air at a pressure of 40 lbs. to 90 lbs. per sq. in., make from 160 to 280 blows in a minute, the force of the blow being from 5 lbs. to 1,500 lbs. at will. Electrical percussion drills have been tried, but so far have not met with uniform success.

Finally a chain-cutter, recently introduced by Messrs. Mather & Platt, Ltd., Manchester, is illustrated in plan and elevation by Figs. 19 and 20. This draws itself along rails with a worm and ratchet device, and has a four-pole motor with self-oiling bearings and carbon brushes. The motor drives a chain carried on a rolled steel jib, the slides for the chain being planed. The main gearing is of steel, and includes a four-thread worm working in a phosphor-bronze wheel, the thrust being taken on ball bearings. The jib will cut its own way into the coal for the start, and, being arranged to swing horizontally through a half-circle, will cut either right- or left-handed in the coal face.

The "Houille Blanche" Congress in France.

By M. F. LOPPÉ.

(Member of the Société des Ingénieurs Civils de France.)

(Continued from Vol. VIII., page 488.)

AFTER having assisted at the conferences in the morning of the second day, the members of the Congress divided themselves in the afternoon into two groups, one party visited the installations of the Société de Fure et Morge at Champ, and the other the plant of the Société des Forces Motrices du Haut-Grésivaudan.

Champ Installation.

The station employs a derivation from the river Drac, of 18 cub. m., under an effective head of about 31 m. The source of the Drac is in the Upper Alps, and it is a very capricious river. The average low-water current is 20 cub. m. (It should be noted, however, that the flow at times of exceptionally low water is 17 cub. m.) The average flow is 35 cub. m. In times of flood this flow reaches 1,200 cub. m. It carries a great quantity of sand and gravel, and, on leaving the ravine of Avignonet, it slackens in the plain, and extends to a breadth of a kilometer.

The intake, Fig. 19, is installed at the neck of the gorge. The dam is of concrete, resting on three piles of pieux, and it is protected by rock pilings.

The side outlet, with a width of 16 m., has a sill, the floor of which, at a level of 299·00 m., is formed of an oak bottom, which resists the action of the pebbles better than would masonry work.

The vanes, of 8·00 m. in width, and of 1·50 m. in height, are formed of a steel apron of 10 mm. thickness, supported by two solidly braced beams. Each vane carries two racks, meshing with steel pinions, fixed on a shaft controlled by a worm gear, which may be operated by one man from a gangway. The intake is provided with openings pierced in a longitudinal wall, forming part of the right bank of the river, and is furnished with vanes (Fig. 19). In front of the openings is situated a grating with a length of 35 m.

The bars of the grating, with a length of 2·20 m. and a cross section of 7 by 125 mm., leave spaces between them of 50 mm. These bars are carried by three long interlacing bars placed horizontally, and fixed by iron stays to the wall, and which support the gangway at a level of 300·63 m., used for cleaning the grating.

The top of the side-wall, moulded by means of compressed air, is levelled at a height of 302·80 m., and serves as a footpath for controlling the intake vanes, and is connected to the service bridge for operation of the side outlet vanes.

Each of the openings in the side-wall has a width of 2 m. and a height of 1 m.5. The sill is at the level of 299·00 m. (the bottom of the intake, under the grating, being at a level of 298·60 m.), and is provided with a vane.

The oak apron, 2 m.10 in width of each of the vanes, is divided into two parts, the lower of 0 m.60 in height and the upper part of 1 m.10. On lifting the vane by means of a small winch, the upper panel lifts about 1 m.; then the lower part commences to lift. A double advantage is obtained from this arrangement:

(1) Starting effort is less.

(2) In high-water the upper part only is lifted; the lower part thus increases the height of the intake overflow thus carried from 0 m.40 to 1 m. This is a great advantage in case of a torrent having considerable fluctuations of heights of the floods.

The decantation chamber has an area of 3,000 sq. m., and it is provided with an overflow and two discharge openings of 2 m. in width, each fitted with two vanes.

The sill of the openings is at a level of 298·7 m.

The basin is separated from the feeding canal by a wall, the top of which is levelled at 299·30 m., forming the overflow. Beyond this wall the canal narrows down to its normal width, and has a slope of 0·35 per kilometre and a length of 600 m.

The intake is trapezoidal in shape, and is 22 m. wide at the intake. The bottom is of gravel and the banks are made up, the part beneath the surface of the water being coated with a smooth lining of concrete, called hydraulic. The canal ends at a new decantation chamber of 900 m.2, which communicates by an overflow, surmounted by a grating, with the charging chamber at the entrance of the forced conduit. The decantation chamber, the average depth of which is 4 m., is limited by a wall forming the overflow, in which are placed 600 openings closed by vanes made entirely of metal, of the height of 0 m.80 and a width of 1·05 m., operated from a gangway placed over the overflow channel.

The grating separating the basin from the charging chamber has a length of 30·50 m. and a height of 3·25 m., and is formed of a series of panels of 1·25 m. in width, made of iron bars of 5 by 60 mm. in dimensions, interspacings of 30 mm. being provided. Nine metal cross-pieces support the grill and the gangway, and are fixed securely to the retaining wall. The gangway above-mentioned is placed for the purposes of cleaning the grill.

The forced conduit is 3·30 m. in diameter, and originates at a level of 295·65 m. The conduit connects to the wall, forming part of the intake chamber, by an enlarged section. The opening is closed by a vane of 4 m. in height and 3·55 m. in width, with a steel sheet apron of 5 mm. in thickness. The whole is braced by T-irons. To avoid too great a pressure when the conduit is not in use, in the lower part of the shell of the vane two openings of 1 m. wide and 0·15 m. high are provided, closed in their turn by smaller vanes. These small vanes operate by means of a special independent mechanism, allowing the conduit to fill up and balance the pressure on both sides of the vane. The operating winch must overcome an effort of 5,000 kg. It operates a direct traction on two steel racks fixed in the vane, and at the same time operates a set of ball bearings of cast iron, which have a speed of at least half that of the vane, so that the sliding friction is in part replaced by rolling friction. The joints are made waterproof by means of copper plates, so that the conduit may from time to time be emptied and cleaned, though the intake chamber be filled with water.

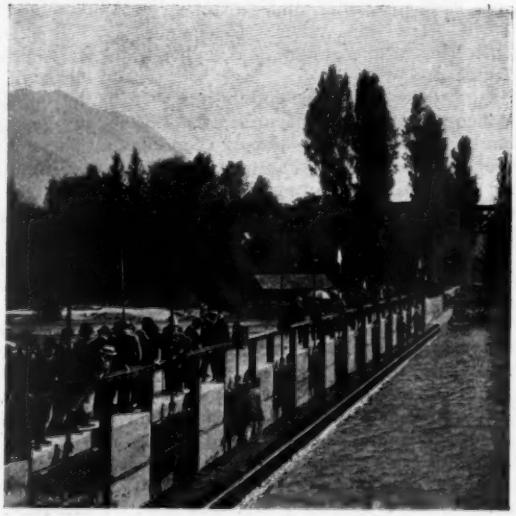


FIG. 19.—CHAMP INTAKE CHAMBER FROM OUTSIDE.

All the valves and vanes were made and installed in position by Messrs. J. Joya, of Grenoble, which firm has also executed the contract for the compressed air founda-

tions of the sill of the moving vanes of the dam, above mentioned.

The forced conduit of 3·30 m. in diameter has a total length of 4,600 m. The first 2,100 m. are constructed of armoured cement, the remaining 2,500 m. being of steel plating. In the length of the conduit are installed three piezometric tubes. The first, of armoured cement, at a height of 9 m., is placed at 400 m. distant from the intake chamber. The second tube is situated at the point of junction of the armoured cement part of the conduit with the iron or steel conduit, and is formed also of armoured cement. It has a height of 20 m. and a diameter of 1·10 m. The third tube of the conduit is placed near the station, and its height is 35·50 m.

The armoured cement conduit rests on a concrete bed of 0·30 m. thickness. The round iron braces surrounding the conduit have diameters varying from 11 mm. to 22·5 mm., and the longitudinal bars, which interlace with the bars surrounding the conduit, have a diameter varying from 6 mm. to 12 mm. The whole forms a sort of trellis-work, with meshes of 10 cm. or 11 cm. These meshes are then filled in with cement, varying in thickness from 20 cm. to 25 cm. The metallic part of the conduit rests on a cement bed of ·50 m. in thickness, and the conduit is covered with a layer of earth of 40 cm. The conduit cannot be deformed during the filling.

The first part of the conduit, of which the thickness varies from 7 mm. to 10 mm., was furnished and placed in position by the firm of Bouchayer & Viallet, of Grenoble.

The last portion of the conduit, as well as the collector and the piezometric tube at the end was furnished by Messrs. J. Joya. Each ring of the conduit is formed of three sheets of steel of 1·55 m. in width. These sheets are connected to each other by double rows of rivets 20 mm. in diameter. Two rings (one small and one large), are united by one row of rivets, the distance of the two rows of rivets from each other is 1·486 m.

The pipe was brought from the construction shop in lengths of about 10 m. A track was formed on each side of the concrete bed of the conduit, and on this track a double wooden pole was placed. Each end of the section was then taken by a tackle capable of handling 6,000 kg., and lowered in place and connected. The riveting of the circular joints was then done by hand.

The collector terminating the pipe has a thickness of 10 mm., and a length of 41·80 m., and the same diameter as the conduit. The thickness of the sheet steel is usually 13 mm., and the sheets carrying the vertical tubes are 15 mm. in thickness. There are six tubes for the intake 2 m. in diameter, and two of 2·080 m. in diameter. The collector rests on a concrete bed, and its complete immovability is effected by means of corner irons. A vane placed at the bottom allows the accumulated sand to be evacuated.

The last piezometric tube of the open-air chimney (Fig. 20) has its top 37·50 m. above the axis of the collector. This tube rests on a block of concrete, and is united to a bend in the collector. Its bottom diameter is 3·30 m., and diameter at the top 1·40 m. An iron ladder is arranged in the interior. At the top is an expansion cup, of 3 m. in diameter and 2 m. in height, by which water is led to the outlet canal by means of three tubes of 65 cm. diameter placed outside the main pipe.

Eight lightning arrester points are arranged at the top, 1 m. in length. A float, operating an index placed outside the tube, allows the oscillations of the water to be observed; and a small connection has been made to this tube to allow the necessary water to be led away to cool the transformers. The construction of this tube was effected by means of a light wooden stay, as shown in the reproduced photograph, which was handed to us by Messrs. Joya (Fig. 21).

The station itself is in two parts, and includes, at the collector end, an underground and a level floor, the latter used as a machine room, the remaining forming the first floor of the station. The outlet canal is situated under the collector, the water-tubes feeding the turbines at first crossing the underground chamber, then

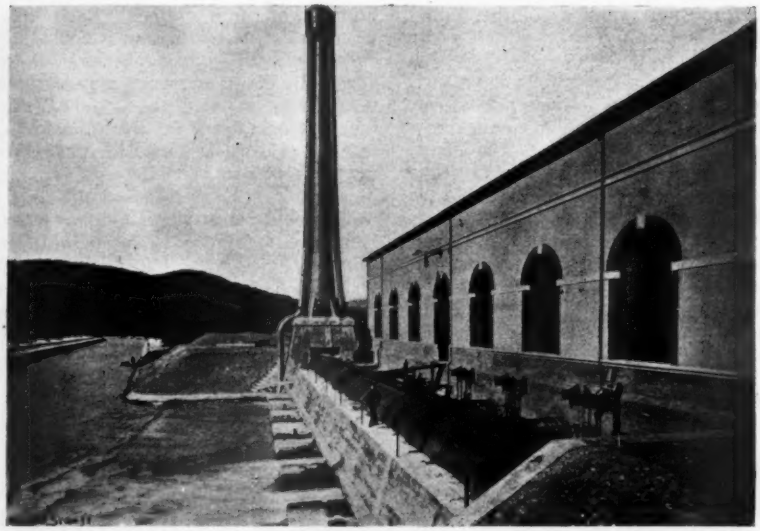


FIG. 20.—OUTSIDE VIEW OF CHAMP STATION AND PIEZOMETRIC TUBE.

connecting to the turbines placed on the level or ground floor.

There are now installed five groups of turbo-alternators of 1,350 h.p., and two turbo-exciter groups of 150 h.p., and a 5 h.p. turbine running the oil compressor pump, intended to actuate the servo-motors (Fig. 22).

The turbines are constructed by Messrs. Neyret-Brenier of Grenoble, and are of the centripetal type. They are provided with cylindrical distributors, operated by governors by the intermediary of servo-motors (hydraulic). Three of the main turbines running the alternators are fitted with a compensating vane which opens when the distributor closes, so that the conduit which feeds the turbine always carries about the same quantity of water, 4 cub. m. This is intended to avoid the recoil effect in the long conduit, where water is brought at a speed of over 2 m. The efficiency of the turbines is 76 per cent.

The alternators are run direct coupled by means of compressed elastic rubber couplings. The speed is 300 revolutions per minute. The number of poles of the revolving field is 20, the frequency being therefore 50 cycles. These three-phase alternators, constructed by Brown, Boveri & Co., give 1,350 h.p., with the cos. ϕ = 0·80 m. The tension is 3,000 volts. Their insulation has been tested at 6,000 volts. The efficiency obtained for a cos. ϕ in test is 0·945 m. With cos. ϕ it was 0·838 m. The temperature rise at maximum full-load charge was 35 degs. At full charge for cos. ϕ 1 m.; the drop in voltage is 4·7 per cent. For cos. ϕ 0 8 m. it is 13 per cent., and for cos. ϕ 0·70 m. it is 15 per cent. The two exciters, of 150 h.p., give a tension of 110 volts. The speed is 500 revolutions per minute, and they are shunt excited with field rheostat, and feed a circuit to which are connected the exciters of the alternators, in each circuit of which are arranged regulating rheostats operating either separately or collectively by means of a handle from the distributing switchboard. The efficiency of the exciters at full charge is 92 per cent., and at half-load is 89·5 per cent. Each alternator feeds a transformer of 1,150 kilo-watts.

The three first windings of the transformer from which the induced E.M.F. is 15,000 volts, can be coupled by means of commutating levers, that is, in delta, and the resulting primary voltage is 26,000 volts (about), that is, 1·42 by 15,000. This arrangement was adopted, as the good performance of the line at 26,000 volts was not a certainty in so variable a climate as the valley of the Isère. Tests have shown that the voltage could be safely employed, and it has been adopted in service.

The transformers have been installed in a special room on the floor level at the opposite side of the building (Fig. 23). This room is opposite the collector end of the building, and its flooring is partitioned off from same. Each transformer has an oil bath, and is cooled by a coiled tube with circulating water flowing at the rate of 30 litres per minute, at the temperature of 15 degs. C. The maximum temperature of the transformers reaches 44 degs. C. Insulation tests were made at 60,000 volts between windings of the high-tension side and the core, as well as between the high and low tension windings, and 7,000 volts between the latter and the base. The efficiency at full charge is 97·8 per cent., and at half-load 97 per cent., and at quarter load 95 per cent. The drop in voltage is 1 per cent. for cos. $\phi = 1$ and 45 per cent for cos. ϕ 0·80.

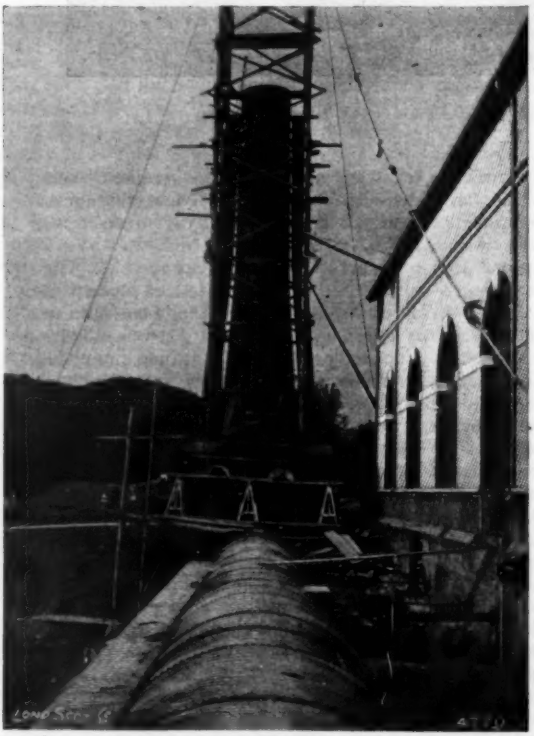


FIG. 21.—SHOWING CONSTRUCTION OF CHAMP PIEZOMETRIC TUBE.

The cables from the alternators are distributed underground and conducted to a switchboard installed on the ground-floor level, on which are installed oil switches for putting the transformers into the circuit, the measuring apparatus and the fuses being separated by marble slabs. The whole of the connections and switchboard has been tested at 6,000 volts.

The six cables from the secondary transformers (Fig. 23) connect to terminals placed on a switchboard on the first floor behind the general distributing switchboard. On this switchboard are arranged bars permitting the primary windings to be arranged in either star or delta to three conductors, with the intermediary of fuses and to terminals of a three-phase switch of the horn type, connecting the transformers to the general high-tension bus-bars of the switchboard.

A step-down transformer for the voltmeter is installed on the switchboard, also ground detectors.

From the general bus-bars start two lines, on each of

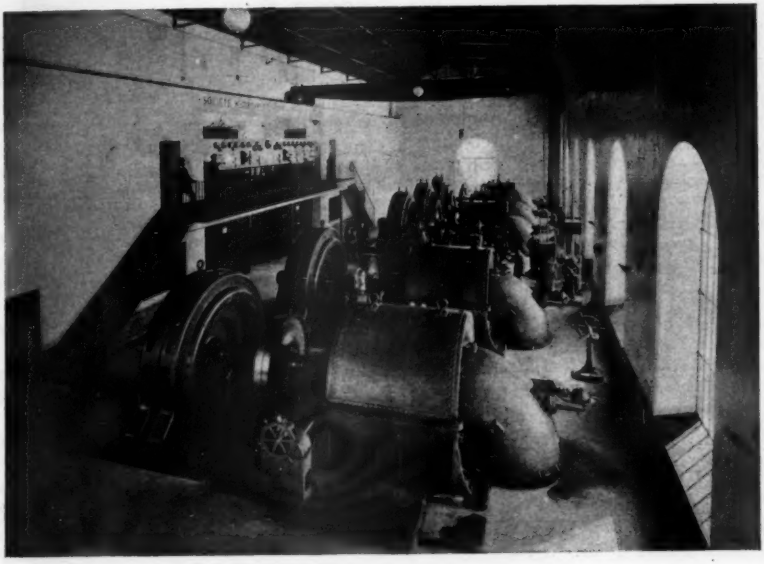


FIG. 22.—INSIDE VIEW OF CHAMP GENERATING STATION.

which are two three-phase oil switches and a fuse. Measuring instruments are connected to these bus-bars by means of step-down transformers installed on the switchboard.

The switchboard has been tested for 52,000 volts.

The glass insulators employed for the installation have a diameter of 175 mm., and a height of 143 mm., and are all tested at 80,000 volts before use.

The line has a length of 36 km. between the station and Moirans, and is set on the same metallic poles as the Avignonet line, each pole carrying the wires belonging to same society on the same side. One can thus install nine wires for each Society. The poles are connected to the ground from place to place, at equal distances.

Every 12 km. is placed an interconnecting post, allowing all the wires to be connected, so as to permit an uninterrupted service in case one of the wires should be ruptured.

Both lines are arranged so that the machines run in parallel on each side of the pole. Lightning arrester posts are also installed on the poles.

The total height of the fall is 37·40 m., and effective height is 32 m. The minimum is 17 cub. meters, so that the power of the turbines is then 5,338 kilo-watts.

The efficiency of the station is

$$0{\cdot}76 \times 0{\cdot}94 \times 0{\cdot}975 = 0{\cdot}697.$$

The minimum available power at the terminals of the station is 3,718 kilo-watts.

The efficiency of the line as far as Moirans attains 94 per cent. The efficiency of the secondary lines and network is 90 per cent. So that the efficiency between the hydraulic power and the consumer is 58 per cent., and the minimum power at the consumer's network is about 3,000 k.w. The Society has already contracted for 2,400 k.w. for the period of 30 years. The industries which have passed these contracts have formed a syndicate. The price per horse-power per 24 hours is frs. 150, that of a horse-power year, at the rate of 12 hours per day, is frs. 125. The energy is delivered quantities of 5 to 200 h.p.

On the return from Grenoble, the Congressmen profited by a stop in the tramway to visit the substation of Galochère, which feeds the tramway from Grenoble to Uriage. This substation, which was installed by the Westinghouse Society, receives 10,000 volts three-phase current and transforms it to 600 volts continuous current for tramway service.

Plants of the Société des Forces Motrices du Haut Grésivaudan.

La Société des Forces Motrices du Haut Grésivaudan provides energy for lighting and power to the town of Chambèry, and possesses two stations — one installed at Cernon, near Chapereillan, on the right bank of the Isère, utilising the fall of the river Cernon; the other, Bréda station, near Pantcharra, on the left bank of the Isère, fed by the river Bréda. The latter plant alone is now working, but it is expected that the station at Cernon will have to assist at certain times of low water.

Cernon Plant.

The river Cernon has its sources on the slope of Mont Garnier, 1,994 m. altitude, belonging to the Grande Chartreuse chain. In these calcareous mountains, where the ground is full of fissures, there are in many places neither ice-fields nor lakes forming natural reservoirs, nor forests for regulating the flow, which is, therefore, exceedingly variable.

After storms or the melting of snows, the source of the Cernon gushes violently from a grotto, the entry of which is obstructed by a cone of rubbish or *débris*. The volume is then increased by several hundred litres, which during the period of low water, or dry seasons, falls to as little as 30 litres, the water hardly filtering through the cone of *débris*.

In 1895 the Société Générale d'Électricité was formed in Lyons, in order to equip the Cernon fall, and serve the town of Chambèry and a number of neighbouring villages, and to supply a calcium carbide manufactory which the Société was installing in Chapareillan. The

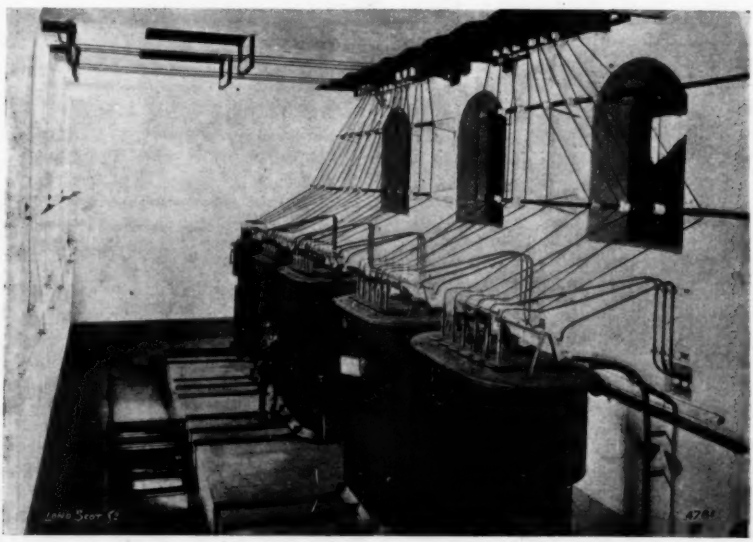


FIG. 23.—STEP-UP TRANSFORMERS OF CHAMP GENERATING STATION

FIG. 24.—MASONRY DAM AND INTAKE OF BRÉDA STATION.

example of this society is interesting in view of the proof it gives of the necessity of prudence in the installation of plants fed by torrential rivers, especially when these plants are destined to supply energy for lighting and power. The society in dry seasons was unable to fulfil its engagements.

It will be seen that a flow of 30 litres per second with a fall of 612 m. represents on the turbine-shaft a power of—

$$0{\cdot}01 \times 30 \times 612 = 183{\cdot}6 \text{ h.p.}$$

A reservoir of a capacity of 1000 m.3, which is situated near the fall, stores an energy equal to 0·0028 VH h.p.-hrs. $= 0{\cdot}0028 \times 612000 = 1713{\cdot}6$ h.p.-hrs. Therefore, assuming five hours' lighting, the total average power available—

$$= \frac{1713{\cdot}6}{5} + 183{\cdot}6 = 526 \text{ h.p.,}$$

which was absolutely insufficient, so much so that the effective capacity of the reservoir was decreased rapidly by reason of the lack of water from the torrent; and the works which could be constructed for avoiding this are exceedingly difficult, if not impossible. Thus, in 1898, the Société Générale failed, and the Société des Forces Motrices du Haut Grésivaudan bought the concessions, the Gorge plant, together with the calcium carbide factory, and took in hand the improvement of the Cernon fall, and made the service up to January, 1900, the date at which the Bréda plant was put into operation.

The intake of the Gorges plant is at the lower part of the dam, and a vane operated from the top of the latter controls the entry of the feed conduit. The latter was installed by the Maison J. Joya, and has a length of 3,200 m.; its diameter is 30 m. The thickness of each section of 6 m. in length varies from 4 to 14 mm.

The joints are flange joints made watertight with lead. In front of the collector a vane is placed, allowing the conduit to be cut off. The collector has a diameter

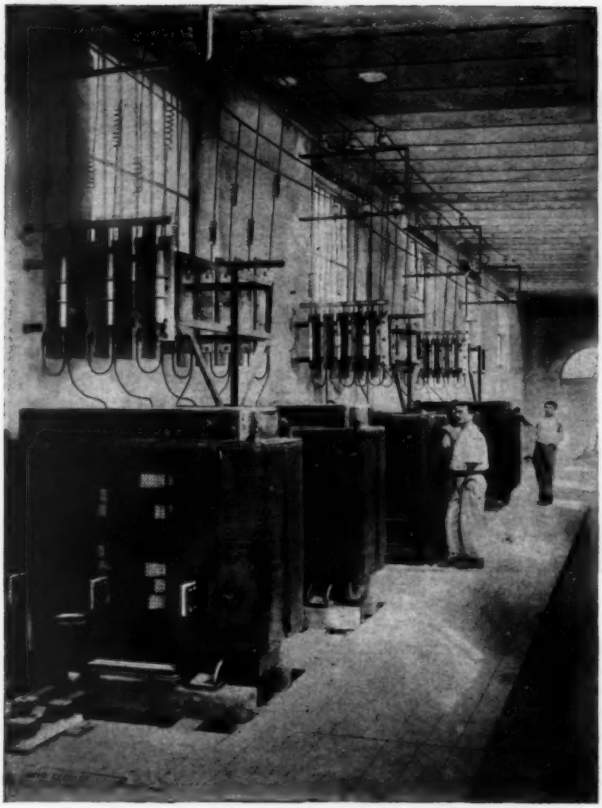


FIG. 25.—STEP-UP TRANSFORMERS 120/10,000 OF BRÉDA GENERATING STATION.

of 0·35 m., and the thickness of the iron sheet is 25 mm. It carries the intake tubes for four turbines, and at its lower extremity a drain-cock is adapted, ending directly at the Cernon river.

In the station two hydro-electric groups are installed. The first series of two groups are formed by a centrifugal turbine constructed by Bouvier, of Grenoble, direct coupled to a Creusot single-phase alternator of 2,000 volts, 20 amps., 42 cycles. Each of these groups is connected to a special switchboard.

In the second series two hydro-electric groups are each composed of a centrifugal turbine, constructed by Brenier & Neyret, of 350 h.p., direct coupled with two labour alternators with two rings. Each ring gives 750 amps. at 120 volts tension, and the speed is 350 revolutions per minute, the frequency is 42 cycles. The 120 volts current is stepped up by means of labour transformers of 120 kilo-watts.

When the Société du Haut-Grésivaudan bought the station certain improvements were made in the fall. A spring, in the very bed of the Cernon river, was found some 106 m. below the dam, and this was intercepted by means of a small dam. This spring gives 15 litres per second during the low water.

A conduit, starting from the new dam, brings water to the original conduit, and a set of vanes allows the simultaneous collection of water from both sources.

The water from the higher dam arrives without pressure; thus at low water a power of $0{\cdot}01\ (30 + 15)\ (612 - 106) = 227{\cdot}7$ h.p. at low water, instead of $0{\cdot}01 \times 30 \times 612 = 18{,}316$ h.p., at which figure the previous flow of water stood before the erection of the new dam. During the utilisation of the water from the old dam, the water from the newer spring is of course not employed, nor allowed to flow in the conduit. The conditions of the water supply for the station were thus somewhat improved.

The manufacture of calcium carbide was resumed for several months during the high water, but was soon shut down from other causes.

Bréda Station.

The Bréda stream is also a torrential river, but as its basin derives its flow from the massive granite chain of Belledone, where are to be found icefields and a number of lakes, seven in all, forming a natural regularisation, the flow is much more uniform than that of Cernon, and never becomes less than 3,000 litres a second. A scheme for regulating flow of these seven lakes is under study at the present time.

The dam (Fig. 24) is situated about 5 km. above the Pontcharra stream, and is in the form of an arc. Its thickness at the base is 4 m., and 1·50 m. at the top. To avoid the baring of the dam, pine stocks are placed at its lower side. Outlets are fixed at each side of the dam; the one off the right bank is fitted with a vane, and the left bank has two vanes placed in position. The intake is on the left side of the river with a grating. There are three discharge vanes to expel the gravel accumulating in the intake chambers.

The feed canal has a length of 280 m. and the speed of flow is 2 m. per second; the breadth is 2 m., and depth 1·50 m. In it are placed thorn fascines for holding and collecting gravel and leaves. These fagots are withdrawn from time to time for cleaning. The system has given good results. The canal ends in a rectangular tunnel of 3 m. × 2 m. pierced in the rock, the length of which is 3,600 m. and the inclination 0·7 mm. per metre. It can give a volume of water of 6 m.3 at a speed of 1·60 m. per second. The water chamber for charging conduit has a length of 28 m., a width of 3·70 m. and a depth of 2·5 m. it is fitted with a grating and discharging vanes.

The forced conduit is not furnished with vanes up-stream; the length is 185 m., including 37 sections of 5 m. Its thickness is 7 mm. It is let into the rock, and rests on masonry supports. It crosses the river Bréda on a metal footbridge of 19 m. span, and extends along the station premises, forming a collector. The height of the fall is 4·25 m., and the mechanical power on the shaft of the turbines at low water is, therefore—0·01 × 42·5 × 3,000 = 1,275 h.p. In times of average water supply it is 3,000 h.p.

In the station building, which is 40 m. in length by 15 m. in width, are installed four groups (hydro-electric), operated by a centripetal turbine with suction pipe, of the Brenier & Neyret type. Two of these turbines are fitted with governors of the hydraulic servo-motor type. The output of these turbines at full charge is 1,170 litres; their efficiency is then 78 per cent. when running at a speed of 300 revolutions per minute.

Each turbine is connected to a three-

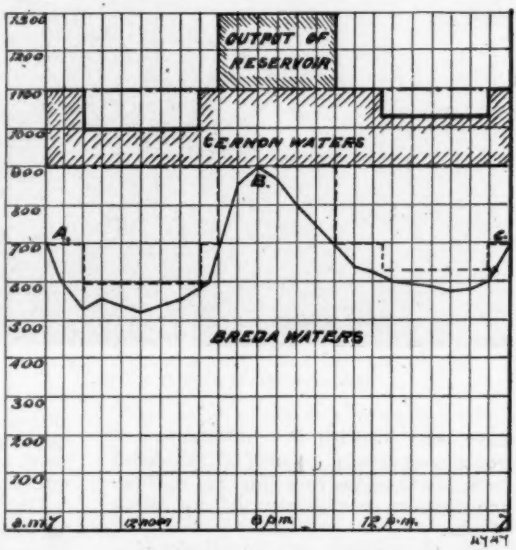


FIG 26.—DIAGRAM OF COMBINED OUTPUT OF BRÉDA AND CERNON WATERS.

phase alternator at 50 cycles, 120 volts tension. Two of these were furnished by the Oerlikon works, one by the Société Alioth de Bâle, and the third is by Brown Boveri. These alternators, though of different construction, are very easily run in parallel.

In a room under the switchboard there

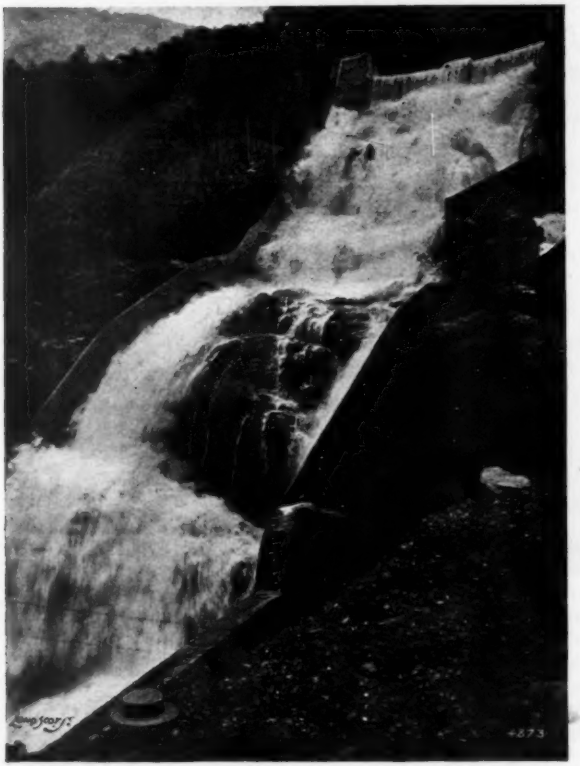


FIG. 27.—OVERFLOW AT LIVET STATION.

have been installed five transformers of 200 kilo-watts each, stepping up the tension from 120 to 10,000 volts (Fig. 25) These transformers were constructed by Alioth Works.

211 transformers, of a capacity varying from 10 to 75 k.w., drop the tension down to 120 from the line tension of 10,000 volts. When a transformer is damaged, it is temporarily replaced by a 75-kilo-watt transformer, placed on a car, so that the interruption is as short as possible.

The most remote customer supplied with energy is at a distance of 45 km. from the station.

As a 10,000-volt current is precluded from entering the town of Chambéry, the line encircles the town, and 19 posts of transformers are installed in brick huts, each of which contains one or two 75-kilo-watt transformers.

At Chapareillan it has been possible to use transformers of an older installation of 5,000 volts. These transformers, which are single-phase, are connected two in series between two phases of the 10,000 distribution. They operate very satisfactorily.

At intervals on the line, Gramont horn type lightning arresters are installed, and also some three-phase switches.

Storms are of very frequent occurrence in this district, and vacillations in the lighting circuit are frequently remarked.

Falling branches of trees often cause short circuits between the cables and their supports. By reason of the sparking the conductor is, of course, injured, and frequent complaints of broken wires are due to this cause.

The Cernon station will serve later as regulator to the Bréda station. M. Juery, Director of the Société des Forces Motrices du Haut-Grésivaudan has studied this pro-

ject. The curve *A B C* of Fig. 26 represents the output in kilo-watts of the Bréda station by amplification of the ordinates of the actual load diagram when the maximum available power is attained, that is, when the 900 kilo-watts actually available at low water will be disposed of. The maximum output curve of the station is nearly reached in the month of December, which coincides with the low water of the Bréda station, for the mountain on which are situated the seven lakes is then under snow.

Fortunately the minimum flow of the Cernon is not just at this moment. It is then always above 50 litres, which represents 200 kilo-watts at the station. By running the Gorges station in parallel with Bréda station, it would then become possible to raise the maximum output to 1,100 kilo-watts. By using the retaining reservoir of Cernon, so as to take water from it during six hours of highest load, the maximum output can be increased to 1,300 kilo-watts. By these several means the actual power can be increased from 900 to 1,300 kilo-watts, that is 400 kilo-watts increase.

The Société has a contract with two stations for supplying power at 100 fr. the h.p. per year, one consuming 150 and the other 100 h.p., and these two consumptions do not coincide with the lighting hours.

There are numerous glove-sewing works which use small motors of $\frac{1}{10}$-h.p. for operating the machines, and the price of energy for each motor has been fixed at frs. 0·10 per day of 12 hours. The following are the selling prices for the town and district of Chambéry :—

1. For day load of 24 hours :—

$\frac{1}{8}$-h.p.	...	...	frs.	37·50 per year.
$\frac{1}{4}$-h.p.	...	...	,,	75·00 ,,
$\frac{1}{2}$-h.p.	...	...	,,	150·00 ,,
$\frac{1}{2}$-h.p.	...	...	,,	250·00 ,,
From 1 to 5-h.p	...		,,	400·00 ,,

FIG. 28.—VIEW OF ENGINS GENERATING STATION AND WATER CONDUIT.

Above 5-h.p., reductions are agreed upon by meter 0·03 per k-w. hour.

2. For 12 hours daily :—
   The prices vary from 300 to 150 frs. per h.p., according to the importance of the contract.
   By meter, 0·03 per k.w. hour.
3. Outside of lighting hours :—
   From 1 to 5-h.p. ... frs. 200 per h.p. year.
   Above 5-h.p. ... ,, 150 ,, ,,

By meter, 0·015 the k-w. hour, with minimum of 100 per h.p. per annum.

For lighting—municipal lighting :—

16-c.p. incandescent lamps, frs. 24 per year.
Arc lamps .. from frs. 8 to 210 ,,
By meter ... 0·03 per 100 k-w. hours.

Private lighting—time meters.

By meter ... 0·06 per 100 watt hours.
32-c.p. lamp. ... 0·08 per hour
16-c.p. ,, ... 0·04 ,,
10-c.p. ,, ... 0·025 ,,
5-c.p. ,, ... 0·015 ,,

Annual Lighting Costs (in francs).

Contract Prices.	At Chambéry.	In other communes, stores and shops open after 10 p.m.	Pro-rata customers and other stores and workshops.
32-c.p. lamp.	90	50	40
16-c.p. ,,	52	35	35
10-c.p. ,,	40	25	20
5-c.p. ,,	25	15	10

The receipts of this Society increase every year, as the demand for energy is daily growing.

SECOND DAY.

Excursion in the Romanche Valley. In going from Grenoble to Bourg d'Oisans, after visiting Vizille Castle, the members of the congress stopped a while at the Claveaux intake station.

A second stop was made soon after at the factory of Rioupéroux.

After lunch at Bourg d'Oisans, the members divided into two parties, the first continued the ascent and slept at Lautaret, and the second party returned to Grenoble, after having visited the Livet station.

Claveaux Factory.—This factory belongs to the Compagnie Universelle d'Acetylène, and is let to the Société d'Electrochimie, which makes sodium. The head fall is 42 m., derived flow 15·3 m. in summer, the season of high water, and descends to 8 m. in winter, or low-water period.

The intake chamber is provided with a top grating with incline, for removal of leaves, similar to the first-described type (Figs. 7 and 8).

The feed-pipe is a slightly-inclined conduit. It has been found necessary, to prevent ovalisation when filling, to set up vertical gratings with cross rods.

Riouperoux Works.

The intake at this station is made entirely of earthbank, with retaining wall. The height of fall is 28 m., and the two conduits are 1·80 m. in diameter, with thicknesses varying from 6 to 8 mm., and a length of 424 m.

Livet Station.

This works was intended for the manufacture of calcium carbide, but is now undergoing transformation to supply the town of Grenoble with electric energy, which town is distant about 45 km.

Thanks to the kindness of Mr. Drouhin, general manager of the Livet station, we were able to obtain some cuts of the hydraulic installation. The dam, built according to Figs. 3 and 4, is 30 m. long, and is in the general form of an arc of 60 m. radius. The side outlet is 6 m. wide, and is provided with three vanes. The top overflow of the admission is 0·60 m. lower than the top of the dam. Above the overflow is a grating of 30 degs. inclination.

After passing the filtering chamber the water passes into the leading canal, constructed underground, the entry to which is provided with a vane. The section of this canal is the area of a circle of 3·75 m. diameter, the slope is 1·5 mm. per m., the speed of the water is 2 m. a second, and the walls are lined with cement.

The intake chamber receives water from the filter chamber which precedes it. Above the overflow, as before stated, are placed three vanes, allowing the filtering chamber to be cut off from the canal. One of the outside walls of the decanting chamber form the overflow discharge for the water thus falling back into the river Romanche, same in position as Figs. 7 and 8. Fig 27, illustrating this overflow, shows the mass of water in excess falling back to the Romanche river.

The feed chamber is placed over the feed conduit, which is vertically placed, and has a diameter of 2·50 m. It is cut out of the rock, with an intermediate lining of cement. At the bottom, the canal bends at right angles, and forms a collector along the length of the factory. The fall is 60 m. high, and the flow can attain 25 m.3.

In the workshop are installed five groups, hydro-electric Neyret & Brenier turbines (arranged like Champ turbines, for constant flow) coupled with single-phase Thury alternators running at 350 turns at 70 volts. The machines are just now undergoing transformation to enable them to give energy to the town of Grenoble. The two 70-volt exciters are separately run by 175 h.p. turbines.

FIG. 29.—INSIDE VIEW OF ENGINS GENERATING STATION IN ERECTION.

THIRD DAY.

The members of the Congress who returned on this day to Grenoble formed two parties. One of these groups visited the Engins factory, and the other the Avignonet factory.

The members of the congress who passed the night at Lautaret visited the electro-chemical factories of Praz, Prémont, and Calypso.

Engins Factory.

The factory is situated near the road to Villars, from Lens to Sassenage, about 15 kilometers from Grenoble. It makes use of a fall, 296 m. in height, tapped from the Furon river. The flow of the Furon river, which is a tributary of the Isère, varies from 200 to 1,500 litres per second, but retaining reservoirs of 4,000 m.3, allow a minimum flow of 300 litres per second.

The feed conduit is made of armoured cement of a diameter of 0·80 m., with a length of 2,000 m. The remaining length of 1,200 m. is formed of sheet steel, with a diameter of 0·60 m.

The building has a length of 34 m., with a width of 16 m. (Fig. 28). There are at

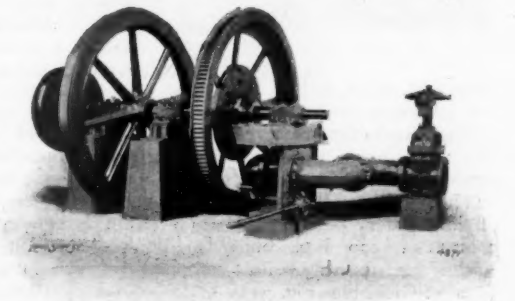


FIG. 30.—ENGINS GENERATING STATION: TURBINE WITHOUT CASING.

present three hydro-electric groups, each consisting of a turbine of 650 h.p., constructed by Bouvier, of Grenoble, and an alternator of 350 kilo-watts.

Fig. 29 shows the arrangement of turbines, and Fig. 30 view of one turbine with casing removed.

The turbines are of the horizontal axis type, coupled with alternators by means of flexible rubber couplings on the Bouvier system. On the shaft is installed a fly-wheel of 3,500 kilogrammes.

station, also operated by a fall from the Furon, 35 m. high, which station comprises one hydro-electric group with a 350 h.p. Bouvier turbine coupled to a Grammont alternator of 350 kilo-watts, giving three-phase current at 250 volts. The exciter is direct-coupled to a separate 20-h.p. Bouvier turbine. A 350-kilo-watt transformer raises the voltage from 250 to 15,000 volts. These two stations are run in parallel.

The overhead lines are supported by

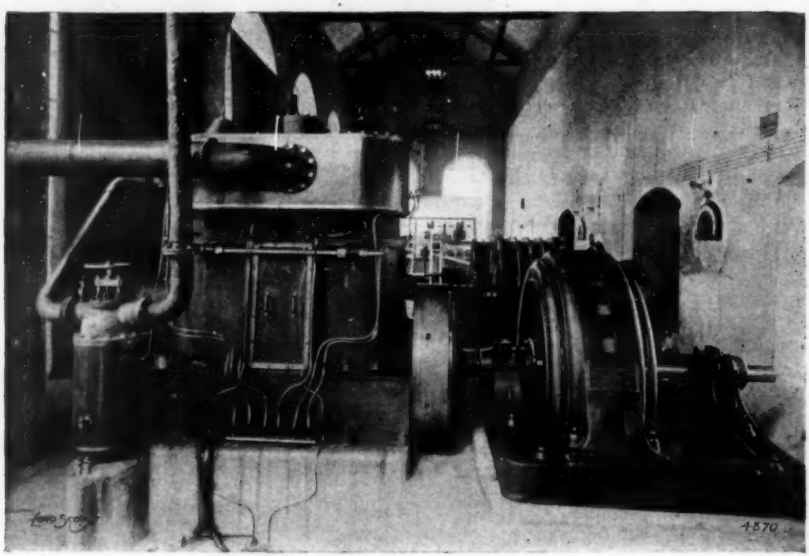


FIG. 31.—RESERVE STEAM ENGINE OF BOULTE-LARBODIÈRE TYPE.

The alternators are three-phase, giving 120 volts, each being supplied with an exciter worked by a special turbine.

The Oerlikon alternator can, in times of low water, be coupled to a steam engine of 500 h.p., built by Boulte-Larbodière, fed by boilers supplied by Joya, of Grenoble (Fig. 31).

A bank of transformers of 250 kilo-volt-ampères raise the tension from 120 to 15,000 volts.

To the same Société belongs a second

poles permeated with copper sulphate, provided with Parvillée porcelain insulators. There are two lines, one with a length of 11 kilometers, with three conductors of 20 m/m². cross-section, and supplied the principal works of the working quarter of Grenoble.

The other line, with a length of 30 kilometers, distributes lighting and power to the town of Voiron, and also to the intervening villages. F. LOPPÉ.

(To be concluded.)

The Construction of Docks.*

By ALEXANDER MacLACHLAN, A.M.Inst.C.E.

(Continued from Vol. VIII., page 390.)

A UNIQUE form of dock is shown in Millwall docks, Fig. 8; a kind of double form of type, Fig. 1. These docks are owned by the Millwall Docks Company. They are angle shaped, with a swinging basin in the corner angle, which, when extended as proposed to Blackwall Reach, will be of type Fig. 5. The water area is 36 acres, and the land 190 acres, or a total of 226 acres; proportion of about 5·3 of land to one of water. The entrance lock, which is bell-mouthed, is 450 ft. long between the extreme gates, and 80 ft. wide, and 28 ft. deep at high water. The docks have a total length of 4,300 ft., and average 350 ft. wide. The docks are chiefly devoted to the grain trade, and are managed by the well-known inventor and patentee of the pneumatic grain elevator and conveyor, Fred. E. Duckham, Esq., M.Inst.C.E.

One of the Great Central Railway Company's docks at Grimsby, the Alexandra dock, approximates to this angled form. This dock has an area of 48 acres, is 6,300 ft. by 450 ft., and has a quayage of 7,370 ft.

The Queen's dock at Liverpool (Fig. 11, C) has been altered to this angled form of dock; it has an area of about 17 acres.

The type of dock Fig. 1 is being constructed by the Clyde Navigation Trustees at Clydebank, on the north side of the river Cart and the town of Renfrew. The area of this dock (Fig. 9) is intended to be about 19 acres. The long arm of the dock, 1,700 ft. long by 250 ft. wide at the east end, and 300 ft. at the west end, will open out into a wide swinging basin of about 600 ft. square, with an open entrance into the Clyde 200 ft. wide, at the south-west corner; a long quay of an average width of 250 ft. being between the river and the south wall of the narrow branch of the dock. This tidal dock will have 25 ft. at low water, and about 36 ft. at high water, and the total lineal quayage 1,850 yds. The area of land for dock, quays, and standage will be 76 acres, making the area of land to water 3 to 1.

At Shieldhall, on the south side of the river and to the east of Renfrew, the Clyde Trust propose constructing a dock of the form of Fig. 2, but an open tidal dock without gates, having the entrance at the north-west corner of the dock, angled about 45° to the river (Fig. 10). The north basin or branch of the dock—that next the river—stretches in an easterly direction about 2,580 ft. by 250 ft. wide, while the south basin, which is shorter, is about 1,930 ft. by the same width. There will thus be a pier or jetty formed between the two basins of at least 1,930 ft. by 300 ft. wide. This long branch dock will open at the west end into a swinging basin 900 ft. east and west, by 830 ft. north and south, with the entrance about 100 ft. wide angled as above into the Clyde on the north-west corner of the dock.

This dock is also to have 25 ft. at low water and 36 ft. at high water, with an area of about 45 acres, and a dock quayage of 4,200 lineal yds. The area of land to water will be $2\frac{1}{4}$ to 1.

The two docks will increase the total wet dock area of $73\frac{3}{4}$ acres managed by the Clyde Trust by 64 acres, a total of $137\frac{3}{4}$ acres.

Morpeth dock, Birkenhead (Mersey Docks and Harbour Board), marked D (Fig. 11), is also of the type Fig. 1. It is $11\frac{1}{2}$ acres, and about 1,350 ft. extreme length, with a swinging basin about 500 ft. square. The entrance is 70 ft. and the quayage 1,299 lineal yds.

There are numerous examples of the type of dock shown in Fig. 2, the single jetty dock. First may be mentioned the

* For Figs. 1 to 19 the reader is referred to pages 382 to 390 of the May issue.

FIG. 20.—SUNDERLAND DOCKS (RIVER WEAR COMMISSIONERS).

Western dock of the London docks (Fig. 12) (London and India Docks Joint Committee). This dock has an area of about 20 acres, and is about 1,230 ft. long by 680 ft. wide, with a jetty about 780 ft. long by 70 ft. wide projecting from the centre of the west quay of the dock. The dock has the advantage of four entrances from the river—the deepest having 28 ft. at T. H. W. —leading through six other docks or basins of a total area of $17\frac{1}{4}$ acres to the main dock.

The next dock shown (Fig. 13) is Parry dock No. 1, belonging to the Barry Railway Company. This dock, devoted to the coal trade, is 73 acres at high water, and 37 ft. 7 ins. deep, with a quayage of 10,500 ft. It is a fine example of the single-jetty dock. It is 3,100 ft. long and 1,100 ft. at its greatest width, the swinging basin in the clear being 1,600 ft. by 1,000 ft., while the jetty averages 1,350 ft. long by 300 ft. wide. The entrance basin, closed by gates 80 ft. wide, is 600 ft. by 500 ft. and 7 acres area. There is a second entrance, a deep water lock 647 ft. between gates and 65 ft. wide. The recent accident to this entrance shows the necessity of having at least two entrances to a dock. The large area of 148 acres of water would have been inaccessible, 107 acres of docks and 41 acres of timber ponds, if there had been only the damaged lock entrance.

Dock No. 2, oblong in

shape, is 3,338 ft. by 400 to 600 ft. wide, and 34 acres in area. It is 37 ft. 7 ins. deep, and the entrance opening from No. 1 dock on the west, is 80 ft. wide and closed by a caisson. There is a large transit shed for imports on the south wall of the dock 500 ft. by 160 ft., and twelve coal tips on the north side, while there are 26 on the quays of Dock No. 1.

The proportion of land to water area at Barry docks is 10 of land to 1 of water, and the width of the main quays for coal shipment 1,000 to 1,500.

The Roath dock, Cardiff (Cardiff Railway Company), is also a single-jetty dock of 33 acres. It is 2,400 ft. long by 600 ft. wide; the jetty being about 800 ft. long by 60 ft. width; the quayage 7,520 ft., and water 32 ft. to 37 ft. deep. The entrance basin (twelve acres) to this dock is 1,000 ft. by 550 ft., and the quayage 2,700 ft., and the inner lock 600 ft. by 80 ft. wide. The dock is given over to coal shipment by the patent Lewis-Hunter coal cranes, which can ship an average of 400 tons per hour, and the jetty to cold storage. Cardiff is the premier port for coal shipment.

The Albert dock, Hull (North Eastern Railway Company), is a quay dock of an area of 24½ acres, 3,420 ft. long, and 300 ft. average width. The length is thus about 11½ times its width. The quayage area is about 22½ acres, and the length of quays 2,371 yds. The lock is 320 ft. long, 80 ft. wide, and has 28½ ft. of water over the sill at ordinary springs.

The North Eastern Railway Company's Victoria dock is 20 acres, with 60 ft. entrance to the river Humber. Along the quays it has 4,000 sq. yds. of jetty accommodation, and a large single jetty for shipping coal from two coal hoists at the rate of 300 tons per hour. The dock is chiefly given over to the guano, seed, coal, and timber trades. For wood cargoes there are provided deal yards of an area of 193,300 sq. yds. or 40 acres, and 10 acres of other space, and three timber ponds of 40 acres. For guano, warehouse space is given for 35,000 tons.

As regards the total money value of cargoes, Hull is the third port in United Kingdom, London being first and Liverpool next, while Cardiff is the premier port for the quantity of coal shipped.

The Queen's dock (Clyde Trust, Fig. 14) is a single-jetty tidal dock of 33¾ acres. The swinging or outer basin is 1,000 ft. by 693 ft.; the north basin, 1,866 ft. by 270 ft.; the south basin, 1,647 ft. by 230 ft., with a quay between, 195 ft. wide. The entrance into the river is at the south-west end of the dock, and is 100 ft. wide. The total length of quayage is 3,334 yds., and the area of the quay space, 26⅔ acres.

The new dock constructing at Grangemouth, now shortly to be opened, is another single-jetty dock. It is 32 acres in area. The swinging basin is 1,400 ft. long by about 940 ft. to 730 ft. wide. The branches of the dock are 920 ft. by 270 ft., and 900 ft. by 220 ft., the jetty between being 930 ft. by 155 ft., and the total quayage 7,510 ft. The new dock opens into the existing docks by a passage about 80 ft. wide. The Firth of Forth is approached by an entrance channel or cut of 18 acres, 200 ft. wide and 4,560 ft. long, widened to 430 ft. for swinging purposes at the entrance lock, which is 640 ft. long between gates and 80 ft. wide, with 32 ft. of water at O.S.T., and 27 ft. at N.T. over sill.

The proportion of land to water is 15 to 1. The cost of this dock is about £535,645, and land £82,000; or about £16,739 per acre without land.

The proposed Renfrew dock, now taken over by the Clyde Trust, is shown in Fig. 15. It was a tidal dock of 16 acres, with one jetty, and a graving dock 740 ft. long. The depth of water proposed was 20 ft. at low water and 31 ft. at high water. The area of land to wet-dock area was 3½ to 1. The length of graving dock was 46¼ ft. per acre of wet dock. The estimated cost of the scheme was £263,063, including £85,447 for the graving dock. Borrowing powers were sought for £335,000. It is said that £152,000 more would now be required to construct this dock to the original plan. The angle of entrance to the Clyde was 45 degs.

The Tilbury docks (Fig. 16, L. and I. D. J. C.) are an excellent example of the

type of double-jetty dock shown in Fig. 3. The area of these docks is 54 acres. The main dock, area 25 acres, is 1,818 ft. by 600 ft., and the depth of water 38 ft., and the quayage 2,750 ft. The centre branch dock is 1,600 ft. by 300 ft., 11 acres area, and the quayage 3,500 ft.; and the east and west branches, each 9 acres area, and 1,600 ft. long by 250 ft. wide; a total area of 54 acres. The two jetties between the branch docks are each 400 ft. wide and 1,600 ft. long. The entrance lock is 700 ft. long between the gates, 80 ft. wide, and 44 ft. deep, while the tidal basin is 19 acres, and 45 ft. deep from T.H.W. Parallel with the entrance lock, to one side, there are two large dry docks with access from the tidal basin or main dock. These graving docks are each 846 ft. long by 60 ft. wide. There is enough land available on the west side for extending the docks to double their present size, providing another three jetties, and, above all, a second entrance—very essential to all docks.

Fig. 11 shows the Liverpool and Birkenhead docks (M. D. and H. B.). Examples of the double-jetty dock are shown at *A* and *B*, and show the Alexandra dock, 44 acres, and the Huskisson dock, 28 acres, which last has been altered to have two jetties, like the Alexandra dock, that gets access to the river Mersey by the Canada basin through the Langton dock. (See photographs.)

The total area of docks and basins at Liverpool and Birkenhead is about 550 acres, the lineal quayage 35 miles, and the total graving dock accommodation 15,228 lineal ft. The area of the dock estate 1,611 acres, and the miles of railway 70.

The Prince's dock (Clyde Trust), Fig. 14, on the south side of the river, is a double-jetty tidal or open dock of $34\frac{3}{8}$ acres. The quayage is 3,764 lineal yards, and the area of the quays $38\frac{1}{2}$ acres. The entrance is 156 ft. wide. The outer basin is 1,150 ft. by average of 670 ft. for north part and 490 ft. for south. The north basin is 1,188 ft. by 222 ft. average width. The centre basin is 1,298 ft. by 200 ft. wide. The south basin 1,458 ft. by 200 ft.

The total tidal dock area provided by the Clyde Trust is $73\frac{3}{4}$ acres, and the graving docks 2,006 lineal ft., or a little over 27 ft. to the acre of wet dock.

The Southampton docks, Fig. 17, owned and managed by the London & South-Western Railway Co., are ideal

FIG. 21.—BO'NESS DOCK, FIRTH OF FORTH (NORTH BRITISH RAILWAY COMPANY).
BIRD'S-EYE VIEW OF HARBOUR AND DOCK.

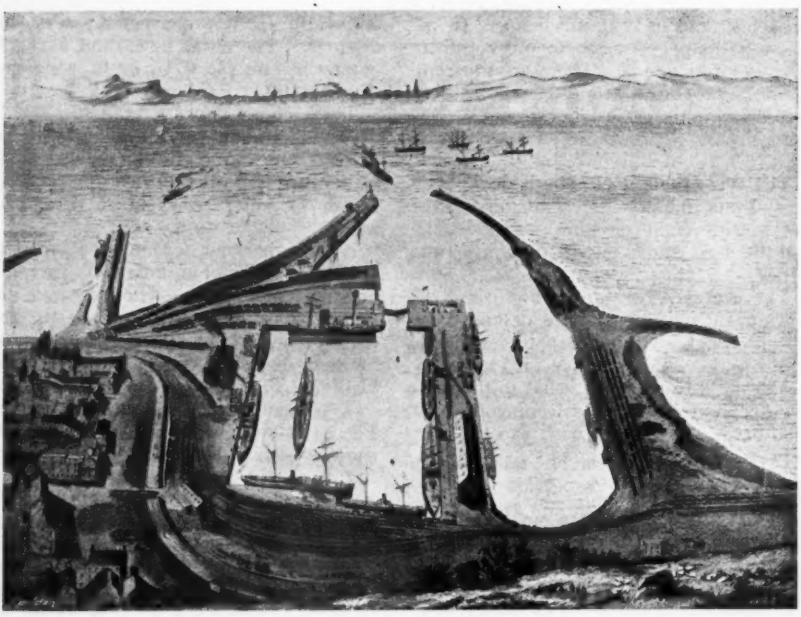


FIG. 22.—BURNTISLAND DOCKS, FIRTH OF FORTH (BURNTISLAND HARBOUR COMMISSIONERS). BIRD'S-EYE VIEW OF HARBOUR AND WEST DOCK.

deep-water docks of up-to-date equipment. The inner dock is a double-jetty dock of 10 acres, 770 ft. by 550 ft. The length of quays 2,500 ft., width of entrance 55½ ft., and depth of water at spring tides 28 ft. The jetties are 200 ft. long. The outer or open dock has 16 acres of water area, and an entrance 150 ft. wide, quays 2,720 ft. long and 31 ft. deep at high water. There is one jetty 250 ft. long.

The Empress dock is an ideal deep-water open dock of modern construction and up-to-date equipment. It is diamond-shaped and of an area of 18½ acres. The dock is 1,720 ft. by 810 ft., quayage 3,460 ft., and entrance 165 ft. wide. The depth at high water spring tides is 39 ft., and at low water 26 ft.

The total length of the six graving docks is 3,292 ft., or nearly 74 ft. per acre of wet-dock area.

The Prince of Wales graving dock was until recently the longest single graving dock in the world. It is 750 ft. long by 91 ft. at the entrance, and has 32½ ft. of water over the sill. The company's new graving dock, the largest of six, is 860 ft. within the gates, 90 ft. at entrance, and has 29½ ft. of water over the keel-blocks at neap tides, and 33 ft. at spring tides.

The deep-water quays have 28 ft. at low-water springs, and 41 ft. at high water. The channel to the sea has 30 ft. at low water.

There are 20 miles of railway lines round the docks, coal-barge docks from which large liners are coaled, and 200,000 sq. ft. of shedding for wood goods.

The Empress dock cost in 1890 £300,000, or £16,216 per acre. It would now cost at least £20,000 per acre. The outer dock in 1851 cost £140,000, or £8,750 per acre.

Fig. 18 shows the Royal Victoria and Albert docks, London (L. & I. D. J. C.). The Royal Victoria dock of the type of jetty dock Fig. 4, has an area of

74 acres, and is 25½ ft. deep. It is 5,400 ft. long, and 1,000 ft. wide, with a quayage of 25,000 ft. There are thirteen jetties. The dock has three entrances; two through the Albert dock, each 80 ft. wide, the two longest 550 ft. and deepest 36 ft.

The West India dock, South dock, and East India import dock, are also jetty docks with eight or nine jetties each, and the East India import dock has two jetties.

The Royal Albert dock, Fig. 18, is a magnificent specimen of the oblong type of quay dock. It is 8,000 ft. long and 490 ft. wide, with a quayage of 17,250 ft. Besides that to the west, it has to the east two deep-water entrances leading from a tidal basin of 15¼ acres, each 550 ft. long between gates, and 80 ft. wide, with 36 ft. and 30 ft. at high water.

Like the Royal Victoria dock, London, the Alexandra dock, Hull, Fig. 19, is a jetty dock of 46½ acres, and of type Fig. 4. The length of the dock is 2,300 ft., and the width 1,000 ft. The length of quays without jetties, 6,200 ft. The jetties, four in number, are 430 ft. to 550 ft. The length of the lock is 550 ft., and the width of entrance 85 ft. The depth of water over sill at O.S.T., 34 ft.; high-water neaps 28 ft., low-water neaps 18 ft., and low-water springs 12 ft. The dock extension is 7 acres, 846 ft. by 530 ft., and quays 2,360 ft., and entrance 70 ft. Four coal hoists each ship 350 to 370 tons per hour. The two graving docks are well placed at the north-east corner of the main dock. No. 1 is 500 ft. on floor, and entrance 60 ft. wide, with 19 ft. on sill. No. 2 is 550 ft. on floor, 65 ft. entrance, and 21½ ft. on sill. The area of land to water is 6·6 to 1. This dock is an admirable example of a modern and well-equipped deep-water closed dock.

Fig. 20 is a plan of Sunderland docks (River Wear Commissioners), showing in the Hudson and Hendon docks the method, according to Fig. 6, of increasing the berthing accommodation by overlapping of berths in jetties and main walls of docks.

The Hudson docks, North and South, have an area of 33 acres, length 2,800 ft., and width 420 ft.; quayage 8,710 ft., and 6 jetties. The docks have three available entrances, one 480 ft. by 90 ft. wide, and depth 28 ft.

The Hendon dock is 11 acres, 800 ft. by 600 ft., quays 2,800 ft, and two entrances, one from Hudson docks, 60 ft. wide, and the other from south outlet. Depth of water over sill 26 ft. at high water.

A large harbour forming the outlet to the River Wear, of an area of 125 acres, is nearing completion. The length of the Roker, or North pier, is 2,790 ft., and the South pier 2,844 ft., and width of harbour entrance 500 ft. with 38 ft. at H.W.O.S.T.

The small dock at Bo'ness of 7⅛ acres, Fig. 21 (North British Railway Company), shows the method of overlapping of quays, Fig. 6, as also Burntisland West dock of 5¾ acres, Fig. 22 (Burntisland Harbour Commissioners). These docks are chiefly devoted to the coal trade, which of late is greatly increasing.

At Burntisland, to the south-east of the old dock, a new dock of 11½ acres, with a quayage of 3170 ft., has been constructed to meet the great increase of traffic. This dock, now opened, has an entrance 60 ft wide, with 28½ ft. of water on the sill at O.S.T., and is equipped with all the latest coal-shipping machinery. Three hydraulic coal hoists each deliver 2,000 tons of coal a day of 10 hours. Height of lift, 40 ft. and maximum load 19 tons. Vessels 400 ft. long can swing within the new dock, and there are seven berths provided ranging from 200 ft. to 570 ft. long. Total cost £400,000, including new passenger pier.

The author is obliged and indebted to the following gentlemen, who most courteously placed the views, plans, etc., at his disposal to illustrate this article, and also gave the information about the harbour and dock works with which they are or have been connected:— To Miles Kirk Burton, Esq.; H. W. Williams, Esq.; John Dixon, Esq.; E. Lake, Esq.; C. W. B. Anderson, Esq.; Richard Evans, Esq.; James Hurman, Esq.; H. H. Wake, Esq., M.Inst.C.E.; and to Messrs. Thomas Meik & Sons.

TOPICS OF THE MONTH.

Motor-Car Racing.

AT the present time, when the world is just beginning to realise that the horse is an expensive and, for many purposes, an unsuitable machine for the purposes of traction, it is very desirable that the subject of self-propelled highway vehicles should be considered calmly and in a judicial spirit. There is no doubt that public opinion has been somewhat excited by the deplorable events attending the recent Paris-Madrid motor-car race, and gloomy forebodings have been made with regard to the forthcoming Gordon-Bennett race in Ireland.

Of these contests, the former has not contributed to our knowledge, although it has served in a most unfortunate manner to emphasise the fact that extremely high speeds are entirely out of the question on ordinary roads, and the latter contest will not serve any practical purpose. At one period in the history of the motor-car industry, speed contests were useful, and undoubtedly have done much towards the development and perfection of horseless vehicles.

Early British cars were only able to proceed on level roads at the most modest pace, and it was almost necessary to push them along on uphill gradients. Meanwhile foreign nations, unfettered by restrictive legislation, were already producing machines capable of real work, and speed trials were of distinct advantage, because they stimulated enterprise on the part of manufacturers, and afforded opportunities from time to time for testing the capabilities of new cars. Without such trials it would have been impossible to bring the motor-car up to its present state of efficiency.

The Value of Practical Tests.

In all departments of mechanical science practical experiment is a most valuable aid to the abstractions of theory, and in machine construction this is especially the case. And in connection with motor-cars it must be remembered that to enable the vehicle to travel at the required speed along bad roads and up hills, there must be a considerable reserve of power. Thus, while the vehicle may only be required to travel some 15 or 20 miles an hour, it must be capable of much greater speed on level ground and under favourable circumstances, although the full speed need not necessarily be used. No one could reasonably expect a maker to satisfactorily comply with all necessary requirements if he were unable to test his work under various conditions. In a new departure such as the motor-car, there were, at the outset, many questions to be answered and many important details to be finally settled by the knowledge to be obtained as the result of actual trials. The design, practicable power, and dimensions of the engine, the design and strength of the frame for withstanding the shocks due to running at full speed over uneven roads, were matters that could not be settled by purely mathematical processes. Much useful information has been derived on points such as these from the racing tests instituted on the Continent. When the use of automotors once more became permissible in this country, makers were at first obliged to trust more or less to theory, because opportunities for practical trials at speeds exceeding 3 miles an hour had previously been prohibited by Act of Parliament. Consequently their machines were far inferior to those of French and other

makers, who had profited by the latitude given by more intelligent governments.

Racing no longer necessary. The stage has now been reached, however, when experiments are no longer required to demonstrate the possibility of high speeds. Speed contests have served their purpose, their work is now done, and they should no longer be permitted on public highways. If car owners find it amusing to participate in races they must do so on special tracks or courses, such as are provided for bicycle or horse-racing. So far as car-builders are concerned, we are quite certain that nothing is to be gained by further enterprise in this direction.

The Car now wanted by the Public. Speed and strength are by no means the only qualifications that should be possessed by a horseless vehicle, whether intended for pleasure or profit. What the public wants is a noiseless and "smell-less" car capable of travelling safely at a speed of, say, 25 miles an hour uphill and on the level, on any road, and in any weather. Price must be moderate, and the car must be strong, well made, and in every way reliable. Some means must also be found of exorcising the evil spirit possessing the average oil motor, that starts when it will and refuses to budge an inch when it will not.

Importance of Details. Those who know anything of mechanical work are fully aware of the great importance of details in the construction of so highly organised a machine as the motor vehicle. Every part must be in exact equilibrium, strain and vibration must be so calculated and distributed that the safety and comfort of the rider may not be in doubt. The arrangement of the machinery for convenience of examination or repair, the silent running of the motor, the effective silencing of the exhaust, the efficiency of cooling devices, brakes, transmission gear, control adjustments, and the thousand-and-one details of the entire machine, all require the most careful attention; and although many excellent cars are now produced in this country, there is not one in which the details are not susceptible of further improvement.

Reliability Tests Wanted. We have already expressed the opinion that speed contests have done valuable work in the past. Equal benefit in another direction is now to be gained by reliability tests, devoted to prove the qualities of the motor-car for continuous work at moderate speeds, and without the necessity for frequent adjustment or repair. A prejudiced section of the public, once deriding the motor vehicle as an inefficient machine, unable to crawl uphill without assistance, has now veered round, and, recognising the ample power attained, is inclined to cry out for protection, but still makes the most of such defects or demerits as are possessed even by the best of motor cars. To remove these should be the earnest endeavour of all who have the true interests of the new industry at heart.

The Future for British Cars. Much has already been done in this direction, and although there can be no finality in mechanical efficiency, we believe that all reasonable requirements in the matter of first cost, combined with general reliability, will be very soon realised. Then we may hope to see the motor replacing the horse for practically all vehicles used in cities and great towns, and for many purposes in rural districts. And we may hope to find British car-builders occupying the premier position in supplying the world's demand for self-propelled vehicles of all kinds.

Amendment of the Electric Lighting Acts.

THE condition of the law relating to the supply of electric lighting in this country has been for some years now a common subject of complaint among those connected with the electrical industry or interested in electricity supply. The original Act of 1882 is still the ruling Act, and although its effect was in some respects altered and modified by the later Act of 1888, there still remain in force several

provisions which militate against proper progress in electric lighting, while other matters, which have now become important, are not dealt with at all. The Acts in themselves are in many respects good specimens of legislation, and when we remember the state of the art of electric lighting in 1882, and even in 1888, we need not wonder that they should now prove defective both in their contents and by their omissions. The full effect of the Acts could not be foreseen at the time, and error is therefore excusable. But when we make full allowance for this, we are still left wondering why these defects, whose existence has been known for many years back and which have been discussed repeatedly in the technical press, should have been allowed to remain on the statute-book up to the present day. The Government has not the excuse that it had no official knowledge of what amendments were needed, for in 1898 a Joint Committee of the House of Lords and the House of Commons—commonly called Lord Cross's Committee—was appointed to consider various questions arising under the Electric Lighting Acts and to report; but no legislation followed upon the report of that committee. At last, however, we have evidence of action being taken, for during the past month there has been introduced to the House of Lords, by Lord Wolverton, on behalf of the Board of Trade, a Bill called the Supply of Electricity Bill, whose object is to amend the present Acts relating to electric lighting. On examining its provisions, we find that they are practically an embodiment of the recommendations of Lord Cross's Committee; and it might be pardonable to ask why we should have to wait till 1903 for legislation which ought to have come in 1898; but let us rather be thankful that something is to be done even at a late hour, and let us examine briefly the nature of the proposed amendments.

Compulsory Purchase of Lands. The first clause empowers the Board of Trade to grant Provisional Orders authorising undertakers of electricity supply to acquire compulsorily lands for generating stations, whether these lands be within or without the area or district of supply, and to extend the provisions of the Electric Lighting Acts authorising the breaking-up of streets, railways and tramways, within the area, to streets, etc., outside the area of supply. Thus it will be possible for companies or local authorities to select the most suitable and most economical sites for their stations unrestricted to their own supply-area, where—as in the case of large towns—sites may be dear; and they will also obtain powers to break up such streets as they require for the laying of mains from these outside stations to the boundaries of their areas of supply. At present, if companies or local authorities desire to acquire land, they cannot obtain powers by Provisional Order unless they make agreements with the owners of the lands. Failing such agreements, compulsory powers can only be obtained by a special Act promoted in Parliament; but it is now proposed to authorise the Board of Trade to deal with this by Provisional Order. As the original Electric Lighting Acts, while incorporating the Lands Clauses Acts generally, expressly excepted the sections dealing with compulsory purchase and entry upon lands, this new Bill, by section 4, repeals that exception and incorporates the whole of the Lands Clauses Act, with certain modifications. If any reader cares to refer to the answers of Lord Cross's Committee to the first three questions put to them, he will see that they recommend practically what is contained in this section of the new Bill.

Supply in Bulk. A question which has come much to the front in recent years is the supply of electricity *in bulk* from some large generating station to various distributing authorities within a wide area. The various power companies which have received statutory sanction since 1900, all hope to induce supply authorities within their area to take current from them in bulk, instead of generating for themselves on a small scale, and as many economies can be made when generation is done on a large scale, it will, no doubt, be cheaper in some cases for supply

authorities—especially in smaller towns—to take advantage of the existence of a power company in their neighbourhood, and to confine their own attention to distribution to consumers. At present, however, arrangements of this kind can only be made by a special Act of Parliament, so in the new Bill it is proposed (section 2) to delegate this power to the Board of Trade in granting its Provisional Orders. The section enables the Board of Trade, by Provisional Order, to authorise any "company or person"—notice that local authorities are here expressly omitted—to supply electricity in bulk within any area for the purpose of distribution in that area by any "local authority, company, or person authorised to supply electricity in the area," and, further, this supply in bulk to distributing authorities may be made compulsory upon the generating companies. This section should prove very useful, as there are many areas in which economy would be gained by generation on a large scale at one point, instead of each little district having its own supply station; but the ultimate value of the section will depend much upon the decision of the Board of Trade upon the question now under its consideration—the question of allowing distribution of current at high tension by overhead wires. So long as companies are restricted to underground cables, with all their disadvantages of cost and difficulties of insulation and capacity effects, the full economy of power distribution and supply in bulk cannot be obtained.

Purchase by Local Authorities. One of the most important findings in the report of the Lord Cross's Committee was that the provisions of the Act of 1888, enabling the local authority to purchase an undertaking after a term of years, are inapplicable, as a general rule, to the case of an undertaker supplying energy in bulk at high voltage, but that there might be special cases where the right to purchase such schemes should still be reserved to the local authorities concerned; and they therefore recommend that the Board of Trade should have power to insert the purchase clause if the local authorities could show good cause why this should be done. Section 3 of the Bill expressly carries into effect this recommendation, as it seeks to enact that the Board of Trade may exclude the power of purchase in the case of any undertaking to which they deem it inapplicable, "either by reason of the undertaking being situate in a large number of districts, or by reason of the objects of the undertaking not being such as can be properly carried out by local authorities, or by reason of any other special circumstances affecting the undertaking"; but before doing so the objections of the local authorities, who would have the power of purchase, are to be considered. The section also extends the powers of purchase by local authorities so as to include generating stations, mains, &c., outside their districts, but used solely for the supply of electricity within their districts, and for this purpose it debars a local authority from purchasing any generating station in their district which is not used for the supply of electricity within some part of the district.

Joint-Boards. Clause 5 provides for local authorities acting together by a joint-board or committee for the supply of electric lighting to any area consisting of the whole or parts of the districts of these authorities, where it appears that the joint exercise of powers of lighting would be expedient. This is no doubt a proper provision, but we fear it is not likely to be used much, as local authorities are too jealous of one another to act amicably together by a joint-board. The ambition to have an electric supply station *of its own* is usually strongly developed even in a small and unimportant municipality, and questions of economy are of minor importance in face of such an ambition.

Abolition of the Veto. The most important clause of all, and one which is sure to meet with strong opposition from the local authorities, is clause 7; for here at last we have what has for so long been demanded—the abolition of the local authorities' veto on lighting schemes.

Section 1 of the Act of 1888 required as a condition precedent to the grant of a Provisional Order the consent of the local authority for the district, unless the Board of Trade should be of opinion, after enquiry, that such consent should be dispensed with; and every one who has studied the progress of electric lighting knows that this provision is very largely responsible for the backward state of the industry in this country. Local authorities have made full use of their veto, and, when afraid of being over-ruled by the Board of Trade, have taken advantage of a rule of the Board of Trade by applying for an order themselves in opposition to the application by a private company, receiving the preference which the rule says they are to have, and then doing nothing to put the order in force. But, if this Bill becomes an Act, the position will be changed, as it provides that, while the local authority is to be heard, the Board of Trade "may grant the order or not at their discretion." This is a much-needed amendment, and we sincerely trust it may become the law of the land. To make the change thorough, the preference given to local authorities in applications for orders ought also to be abolished, and we earnestly hope that the Board of Trade will, if this measure becomes law, alter the offending rule.

Sundry Provisions. The other clauses of the Bill are of minor importance; the most noteworthy being clause 10, which provides that no person shall have a right to demand supply of current to premises having a separate supply unless he has agreed to pay the undertakers a minimum annual sum sufficient to give them a reasonable return on the capital expenditure and standing charges incurred by them in order to meet the maximum demand for those premises. In absence of agreement, the sum to be paid is to be fixed by arbitration. This provision is but fair to the undertakers, as otherwise they may incur heavy loss from supplying such consumers. By clause 7 the period of revision of maximum price is reduced from seven years to five.

General Remarks. In the small space at our disposal, it is not possible to enter upon criticism of the various clauses, and we have therefore confined ourselves to what is in the Bill without reference to its omissions. It will be seen that it introduces several very important and very valuable changes, and for that reason it deserves to become law. We are glad that it should have been introduced first to the House of Lords, as there the municipal authorities, who will be the strongest opponents, have less influence than in the other House, so that the Bill should receive more impartial treatment. The Bill is welcome for another reason, as, taken with recent actions of the Board of Trade in other matters, it tends to show that that Department is now more alive than in the past to the needs of the community, and that it is endeavouring to satisfy those needs.

Engineering Conference.

THE third biennial Engineering Conference, organised by the Institution of Civil Engineers, was held during last month in Westminster, under the presidency of Mr. J. C. Hawkshaw, President of the Institution. Many interesting papers on engineering questions were read and discussed; and although space prevents us from referring to them here, they will be duly abstracted and published in the "Engineering Abstracts" section.

The Congress was opened by the delivery of the "James Forrest" lecture by Mr. W. H. Maw, past president of the Institution of Mechanical Engineers, an abridgment of which here follows.

SOME UNSOLVED PROBLEMS IN ENGINEERING.

The Economical Generation of Power. In a civilised community like ours, no engineering problem is of greater importance than the economical generation and distribution of power, and it behoves us to spare no pains to secure in the heat engines we employ the very highest possible degree of economy. And here it may be well to observe that the term "highest economy" is susceptible of more than one interpretation. To the physicist it will mean the most complete utilisation of the heat supplied to the engine. To the engine user, on the other hand,

it means the engine which will afford the highest return on the money expended on its installation and working. Thus, in some cases, true economy may result from avoiding rather than by adopting refinements by which the economy of the engine from the physicist's point of view may be increased; but to enable him to arrive at a proper judgment on such points, the engineer must be in possession of accurate knowledge as to the heat economies which it is possible to secure by the adoption of certain special designs or systems of working, together with data as to the cost of carrying out such designs or methods in practice. It is, in fact, only when what I may call the "heat economy values" of improvements are accurately known, that their commercial economy can be properly estimated.

It is beyond doubt that the average efficiency of our steam engines as heat motors has, during the past ten or fifteen years, increased in a most material degree, but the fact that many of our best results have been attained by diverse methods clearly shows that we have by no means reached finality, and the question as to how further progress is to be secured is one of the problems to which I desire to direct attention. In his lecture, "On the Development of the Experimental Study of Heat Engines," delivered by Prof. Unwin in 1895, an excellent account was given of the origin and growth of the accepted theories as to the action of steam in an engine, and of the important effect of cylinder condensation on economical working. But Prof. Unwin was careful to point out that, whereas on theoretical considerations alone, the use of steam jackets might always be expected to afford highly beneficial results, yet in practice the economy obtained by steam jacketing varied greatly, and was in some cases a negligible quantity. The causes for this are, to a great extent, known in general terms. For instance, we know that the beneficial effect of jackets increases with an increase in the proportion of the area of the jacketed surface to the quantity of steam passing through the cylinder in a given unit of time, and also that it is apparently affected by the character of the jacketed surfaces. But when we come to quantitative results, we find that our knowledge is far from being of that exact and definite kind which is of real scientific value. And this state of things is reflected in the current practice of our leading steam-engine builders. There are, of course, cases in which the question of jackets or no jackets is settled by considerations of cost or of weights, without regard to economy; but, puting those cases aside, we find a divergence in practice which it is impossible to reconcile with the possession of adequate experimental data. Thus we shall find, say, triple-expansion engines of practically the same size, and designed for the same steam pressures and piston speeds, and working under the same conditions, but constructed by different makers, provided with jackets to all cylinders and covers, with jackets to the barrels of cylinders only, with a jacket on the high-pressure cylinder only, or on the low-pressure cylinder only; with steam at full pressure admitted to all jackets, or with provision or varying the steam pressure in the different jackets; and for all these variations in practice the designers will, as a rule, be prepared to quote reasons which they regard as adequate. Now, the only satisfactory explanation of this condition of things would be that the differences in economy consequent upon the adoption of the variations in practice to which I have referred are so small as to be masked by the differences which necessarily occur in engine management; but, if this explanation were the true one, it would be an exceedingly strong argument for the entire abandonment of jackets in the class of engines under consideration, and for securing the consequent saving in the cost of construction which the omission of such jackets would effect. This explanation, however, is not a satisfactory one, and, in view of the great interests—monetary and otherwise—involved, it appears to me that the whole question of steam-jacketing, and particularly the application of such jackets to compound or multiple-expansion engines of modern types and of large power, using steam at high pressures, deserves a much more thorough and systematic investigation than it has hitherto received.

Here it may be well to point out that there is a great difference between a strictly systematic investigation, such as I have in view, and an ordinary engine trial. Thus, to ascertain why, in a given instance, certain pressures of steam in the jackets of a compound engine have given the best results, we must have full information as to the condition of the steam in each cylinder of that engine throughout the stroke. We must know its pressure, temperature, and the amount of moisture it contains at admission, at the point of cut-off, and at exhaust; and we must be able to trace how far alterations in its condition are due to heat received from the jacket or to other causes. We must, in fact, if we desire to properly investigate the merits and demerits of steam jacketing under various conditions, not be content with ascertaining that in a particular set of instances the use or disuse of a jacket effected or did not effect, economy; but we must trace out the reasons for such results, and be able to account satisfactorily for the disposal of all heat supplied to the engine.

The action of steam jackets is, however, only one of several important problems relating to steam-engine economy at present remaining unsolved. Another is the economic effect of inter-heaters, through which the steam is passed on it way from one cylinder to another, of a compound or triple-expansion engine. During the past half-century, numerous types of inter-heaters have been designed and applied more or less spasmodically, while in recent years the use of such appliances has become a prominent feature in certain branches of American practice. The data on which the use of such heaters is founded, however, are far from being of a satisfying character, and they present discrepancies which certainly require clearing up.

The question of the economy or otherwise of inter-heaters is to some extent mixed up with the

practice of superheating; but at the same time the latter also presents certain problems of its own which are at present far from being satisfactorily solved. It is now nearly half a century since, in 1855, Hirn carried out his historical experiments on the use of superheated steam, and the trials of various kinds which have been made since that time are legion. Those, however, which have a direct bearing on the requirements of modern advanced practice are comparatively few and by no means complete in their character. It is, of course, fully admitted that under many circumstances important—and in some instances enormous—savings can be effected by the use of superheated steam; but in certain cases the engines affording these results are such as to be open to great improvements in other well-known directions, or are working under conditions which, in our present state of knowledge, should not exist. What is really required is accurate information as to the extent to which our most advanced steam engine practice can—especially in the case of large power units—be improved by the use of superheated steam, and as to the manner in which such improvement can best be realised.

A serious defect, moreover, in a very large proportion of the experiments on superheated steam hitherto carried out is that they have been made on the use of such steam in engines of ordinary design, primarily intended to be worked with saturated steam. And, in connection with this matter, I may point out that we are much in want of a thorough determination of the physical properties of superheated steam, extending over the range of temperatures and pressures likely to be employed in practice. Such a determination may, I hope, soon be undertaken. Equally desirable, also, is the thorough investigation of the action of steam—both saturated and superheated—in the various types of turbine motors; a matter which has, as yet, been by no means dealt with so exhaustively as its great and rapidly-growing practical importance deserves, and respecting which many lessons undoubtedly remain to be learnt.

In addition to the various points already mentioned, the question of the economy to be secured by the use of still higher pressures of steam than are now used, requires investigation. The prospect of any very material increase of economy being obtained by such increase of pressure does not appear particularly hopeful; but nevertheless, the facts should be ascertained. It may be pointed out, too, that we are without any direct determination of the latent heat, volume and temperature corresponding to pressure, in the case of steam of pressures exceeding 350 lbs. per sq. in. The published data relating to steam of higher pressures have been obtained by extrapolation, and are by no means strictly to be relied upon.

Altogether it must, I think, be admitted that the steam engine still affords ample field for experimental research; and that such research must be of a character differing widely from ordinary so-called engine trials, and must be carried out by the aid of appliances quite unknown to early experimenters. The classical researches of Callendar and Nicolson on the "Law of Condensation of Steam"* will serve as an example of the spirit in which the questions at issue must be attacked. We have now, in our engineering colleges, a number of experimental engines admirably adapted for dealing with many branches of such research, and quite capable of being so used, without at all interfering with their efficient employment for the purposes of instruction. What is necessary is, that there should be co-operation between the various colleges, and the organisation of certain schemes of research on lines which should enable each institution to carry out that part of the work for which its equipment is best adapted. But in organising such researches it must be borne in mind that the mere aggregation of a large mass of data is far from being all that is required. What is equally necessary is the thorough discussion of such data, the determination of the strong and weak points and the extraction of such lessons as the facts afford. Eight years ago Professor Unwin, when delivering the third "James Forrest" Lecture, and speaking of the valuable experiments carried out by the late Mr. P. W. Willans, said: "The results, tabulated in the clearest way, form a quarry of scientific data, but at present in the main an unworked quarry." This is still quite true; and it is true not only of the Willans experiments, but of many others carried out both in this country and abroad. Now this state of affairs involves the useless repetition of experiments to determine points for the settlement of which data already exist; and it is calculated to permit of the continuance of certain methods of inquiry, which proper discussion would have shown to be either inadequate or misleading. Here, I think, we might take a lesson from astronomers, and, to a large extent, separate the work of discussing experimental data from that of obtaining such data. It by no means follows that a skilled experimentalist and acute observer is the best man to deduce lessons from the results he records, while, on the other hand, the comparison of such results obtained by different observers can often best be made by one who is not himself an experimentalist, but who possesses good powers of analysing and weighing evidence, and who is quick to detect deficiencies in the records, or weak points in the modes of procedure. Of course, it will be most desirable that experimentalists and those discussing the results of experiments should be in close touch with each other—so that faulty methods of research should not continue in use, and that deficiencies in the records should be promptly remedied; but given this free intercommunication, I feel convinced that a division of work such as I have suggested would be beneficial in every way.

Internal Combustion Engines.

Much that I have said about the steam engine applies also to the various types of internal-combustion engines which are now assuming such an important position amongst modern motors. It is often said that internal-combustion engines have reached their present state of efficiency

* *Minutes of Proceedings*, Inst. C.E., Vol. CXXXI., p. 181

almost entirely through the lessons afforded by the more or less crude trials and experiments of their makers and designers, and that they owe comparatively little to the researches of physicists. To a great extent this statement is undoubtedly true; but it is, I think, equally true that there has been reached a stage in the development of such engines at which a really systematic and exhaustive investigation of the conditions under which they work is calculated to afford most valuable aid.

About six years ago the Institution of Mechanical Engineers appointed a Gas Engine Research committee, and this committee has already issued two reports,* which, although they can only be regarded as touching the fringe of the subject, afford an excellent idea of the difficulties to be surmounted in carrying out researches of this character. Not only have entirely new experimental appliances to be devised and calibrated—and Prof. Burstall has shown the greatest resource and perseverance in meeting these difficulties—but it has been found that many of the physical data, upon which we must depend for drawing our conclusions from observed facts, themselves require important revision. For instance, in the earlier experiments on gas engines it was assumed, in calculating the results of the ignition of certain explosive mixtures, that the specific heats of the gases forming the products of the explosion were constant at all temperatures. This assumption, however, is now generally regarded as erroneous, and there appears to be good ground for believing that with an increase of temperature there is a very substantial increase in the specific heats of such gases. While, however, the general fact may be regarded as proved, the numerical data necessary to enable that conclusion to be turned to practical account are far from having been fixed with certainty, and further determinations are greatly wanted.

Again, the value of experiments on internal-combustion engines depends in a most important degree upon the accuracy with which variations of temperature can be observed, both in the cylinder before and during explosion, and in the walls of the chamber in which the explosion occurs. Engineers owe a great debt of gratitude to Prof. Hugh L. Callendar for his earnest labours in perfecting devices for securing accurate thermometric observations at high temperatures; but even with these appliances available, the determination of the temperature of exploded gases is by no means a simple matter. As Prof. Callendar has himself pointed out, the temperature assumed by the platinum wire of an electric resistance thermometer exposed to such gases must necessarily be less than that of the gases themselves, partly owing to the time required to communicate the heat from the gases to the wire, and partly owing to the fact that while it is being heated by conduction the wire is suffering loss of heat by radiation. In dealing with low temperatures this latter loss is a comparatively unimportant matter; but it is a loss which appears to increase as the fifth power of the absolute temperature, and in the case of such temperatures as have to be dealt with in internal-combustion engines it has, therefore, a most material effect. Moreover, the rate at which heat is communicated from the gases to the wire is dependent not only upon the difference of temperature, but also on the pressure, in a way not yet accurately known; and thus the accurate determination of the results of explosions in internal-combustion engines means not merely the skilful use of known appliances, but the determination of certain physical constants involving much expenditure of time and labour. I have mentioned these two instances only; but they might be multiplied almost indefinitely, so numerous are the branches of inquiry which the exhaustive investigation of internal-combustion engines opens up.

Then, again, apart from the problems presented by internal-combustion engines as now made, there are others which may be expected to arise out of the evolution of new types, including, possibly, some forms of turbine-motors. Internal-combustion engines have already realised very considerable efficiency as heat motors, but it is well recognised that they are subject to very important losses of heat by radiation and conduction through the cylinder walls, and by the heat carried off in the exhaust, and efforts are constantly being made to reduce these losses. The governing of internal-combustion engines and the regulation of the powers developed by them at various speeds and under varying conditions are also matters which present many unsolved problems.

Constructional Engineering. Dealing with constructional engineering, Mr. Maw dwelt on the many unsolved problems that remained for the civil engineer to attack. Want of precise knowledge necessitated recourse to factors of safety, which, he said, might be more properly called "factors of ignorance."

In the case of large bridges, roofs, and structural work of that class, there is ample scope for aid to be given by the better determination of the amount and effect of wind-pressure—a branch of experimental inquiry which is at present far from being in a satisfactory state. What is greatly required is a thorough investigation of the action of the wind on surfaces of different areas and shapes, and particularly its effect on partially shielded areas. Amongst other points requiring settlement is the action of wind on the lee-side of roofs—a matter on which the experiments of Irminger have thrown much light, but which still requires further investigation.

In the determination of the stresses induced in the elements of a structure by the forces applied to that structure, there still remain many problems of importance imperfectly solved. The theory of the plate web girder, for instance, is in a far from satisfactory state, particularly as regards the action of web-stiffeners, the stresses on the web itself, and those on the connections between the web

* *Proceedings* of the Institution of Mechanical Engineers for 1898, p. 209, and for 1901, p. 1,031.

and the flanges. The whole subject of resistance to compound stresses—such, for instance, as those existing in the web of a plate girder or a flat-stayed plate, forming part of a steam boiler—is one urgently requiring further experimental investigation.

Then, again, we are now largely using hollow shafts for marine and other purposes, and the relation of these to solid shafts of the same nominal strength, as regards the power of resisting repetitions of varying or alternating stress, has not yet been systematically investigated. Another point is the effect of oil-tempering and different modes of annealing on the endurance of fatigue, a matter which, in view of the effect of similar treatments on the ultimate strength and limit of elasticity of steel, is one of much importance.

The great problem we have still to face—and it is a problem which will tax to the utmost our powers of research—is the determination of what the change which we call elastic fatigue really is. The indications of ordinary testing machines do not reveal any change in the behaviour of a material which has certainly exhausted a large proportion of its "life" under repeated applications of stress, and we must evidently, to solve the problem, have recourse to other modes of inquiry. What is the change of structure produced by fatigue, and in the case of any but pure metals is this change accompanied by any re-arrangement of the constituents? How is this change of structure affected by variations of treatments, by annealing, or, in the case of steel, by tempering?

It is sometimes of considerable importance to ascertain whether a certain object—as, for instance, a propeller shaft, or a portion of a bridge structure, or a steel rail—has or has not been injured by the repeated applications of stress to which it has been subjected; and at present the only method of determining this is the testing to destruction of the object respecting which the information is desired. But if we knew accurately in what part of the object the stresses to which it had been subjected would first cause injury; and if we further knew in what way the existence of such injury would be indicated by change of structure, it would follow that the microscopic examination of a small portion, cut from the most sensitive part of the object, would afford a valuable indication of what was going on.

There are other questions which appeal directly to the users of steel. Amongst such questions are the oil-tempering of mild steel forgings and of steel castings; the investigation of the treatment during manufacture and hardening of spring steel; the examination of the qualities of special steel alloys, suitable for the construction of engine or machine details, in which exceptional strength and lightness are essential; and the production of alloys capable of resisting corrosion and withstanding great changes of temperature, and thus specially suitable for the construction of superheaters and other apparatus in which such changes occur.

Mr. Maw emphasised that, on the latter point our knowledge was meagre and consisted chiefly of isolated tests. The results had shown that the alloys of nickel and iron were the material to be of the greatest value, and the time had come when an exhaustive examination should be made. An alloy iron containing 35 to 36 per cent. of nickel had an exceedingly small change of volume, the linear expansion and contraction under the influence of heat being only about that of one-tenth of platinum—that is to say, it was practically insensible to ordinary atmospheric changes. They had there the singular case of two metals, possessing about the same co-efficient of expansion, giving, when mixed under certain conditions, only about $\frac{1}{13}$th to $\frac{1}{14}$th of that of either of the metals separately.

Electrical Engineering. We have in new steels a series of materials which promise to revolutionise a very important percentage of our machine work, and to necessitate very material alterations in the proportions of our machine tools, involving very heavy outlay, if we wish to advance with the times. Now these are facts pointing to the necessity for extensive research conducted in a thoroughly systematic way.

I have endeavoured to show how desirable it is that the engineer and the physicist should work together in dealing with certain investigations which I have enumerated, and I have done so because, although engineers generally now fully appreciate the aid which physical science can afford, there has not hitherto been such an intimate association of the two classes of workers as is really desirable. But with electrical engineering the case is quite different. We are accustomed to speak of the extraordinarily rapid development of electrical engineering, and the marvellous way in which it is assuming such a paramount position in civilised life, but I do not remember ever hearing this wonderful growth attributed to what I believe to be its real cause, namely, that from the moment that the practical application of electricity became one of the branches of our profession, engineers and physicists have worked closely hand-in-hand to overcome its difficulties, and to elucidate the questions to which it gives rise. The growth of electrical engineering thus constitutes a great object-lesson, sufficient in itself abundantly to emphasise the fact that the future progress of engineering is indissolubly bound up with the progress of physical research.

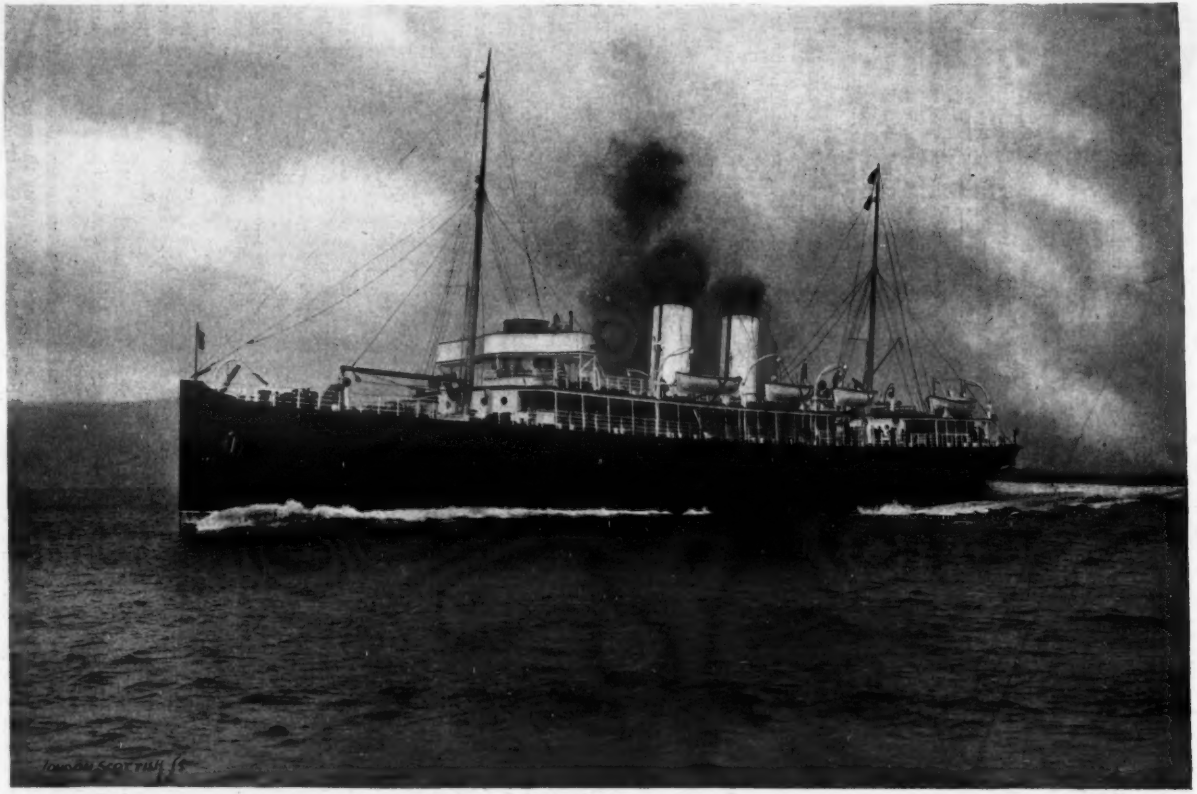
ENGINEERING PROGRESS.

The New Cross-Channel Turbine Steamer "Queen."

THIS new turbine steamer for the South-Eastern and Chatham Railway marks a departure in Cross-Channel steamers. Hitherto these vessels have been of the paddle or ordinary twin-screw type, but the new vessel is a turbine steamer, and is an enlarged example of the vessels which have been so successful for river purposes on the Clyde. The new vessel is 310 ft. long, with a moulded breadth of 40 ft. and a depth of 25 ft., and has a complete awning deck. In large deck-houses on this deck there are a number of special cabins provided for the convenience of passengers. Amidships is the smoking-room, framed in waxed oak in a free, classical design, and upholstered in leather. The seats are arranged in bays with small tables, and the floor is laid with ornamental tiles. Above this first-class accommodation there is a promenade deck extending out to ship's side, which shelters the awning deck in wet or rough weather, and provides a large promenade for passengers in fine weather. The ladies' accommodation is in a large apartment on the main deck, framed in oak and enamelled pine, with a broad frieze of anaglypta. The doors are in leaded glass richly coloured. A feature of this apartment is the fire-place, with brass interior and tiled panels of special design, the overmantel having a beautiful dolphin clock. The settees of the apartment are upholstered in cretonne and arranged with spring seats to form berths for use on the night passage. Immediately below this is a gentlemen's sleeping saloon, framed in panelled oak, with shell pattern frieze and upholstered in rich leather. Abaft this is the restaurant, also panelled in oak, with anaglypta frieze representing ancient war-galleys. Large dining-tables are provided, with revolving chairs, capable of accommodating about 50 passengers. The galley, which is in connection with a pantry above by means of a hoist, is fitted with a very complete appointment of steam cooking appliances. All the first-class vestibules are framed in light oak, waxed, and the interior doorways have leaded glass panels. Twelve state-rooms and two special royal state-rooms are provided for on the upper deck, the former being finished in white enamel with red figured cretonne, whilst the latter are in white, richly ornamented, with upholstery in cretonne to match.

The second-class accommodation is situated aft, the ladies' cabin being in large deckhouse on the awning deck, the roof of which extends out to the ship's side, forming a sheltered promenade in wet weather. The gentlemen's accommodation is on the lower deck, and consists of comfortably upholstered sofa beds for the night service. A large open space is also provided on the main deck as a shelter during the day service. The crew are accommodated on the lower deck right aft, and the officers and engineers on the main deck amidships.

The appliances for working the vessel are exceptionally powerful, and consist of a large windlass and capstan, by Harfield, at the fore end of the vessel, and a warping capstan aft by Messrs. Paul. The rudder, which is large and of the single-plate description, is worked by Messrs. Brown Brothers' steam-tiller, and controlled from the flying bridge by means of the maker's patent telemotor. For convenience in canting and backing out of harbour, the vessel is fitted with a large bow-rudder worked by a steam-steering gear of Messrs. Bow, McLachlan's manufacture, controlled by a wheel on the flying bridge. As very



THE NEW CROSS-CHANNEL TURBINE STEAMER "QUEEN."
Built by Messrs. Denny & Co. Dumbarton.

heavy mails have to be frequently handled on this service, the vessel is provided with derricks and two large winches for dealing promptly with this matter. The vessel is heated throughout the passenger accommodation by means of a system of steam piping, and is fitted throughout with electric light and electric bell installation, this work being done by the builders.

The sidelights, which are large and numerous, are of the "Denny-Porterfield" patent pattern. Special arrangements have been fitted for getting the boats out and in quickly. This gear has been designed by Capt. Pett, of Dover. The idea is to carry the boats out at all times, and to swing them in only when coming alongside the berthing stage.

The propelling machinery consists of Parson's turbines, three of these having been fitted with corresponding lines of shafting, the centre shaft having one propeller, and each of the side shafts two propellers. At full speed the revolutions of the centre shaft will be about 500 per minute, and of the side shafts about 700 per minute. In manœuvring, the centre shaft runs free, the two side shafts and propellers acting as ordinary twin screws. As has been demonstrated in the *Queen Alexandra*, the manœuvring power is in every respect as good as with ordinary twin-screws, while in the going astern there is none of that objectionable vibration which is to be felt in the most modern twin-screw balanced arrangement.

The turbine machinery is on the latest improved plan as designed by Mr. Parsons, and consists of three separate turbines each driving its own line of shafting, the centre turbine being high pressure and the two side ones being low pressure. When going ahead in ordinary work the steam is admitted to the high-pressure turbine, and after expansion there, passes to the low-pressure turbines and then to the condensers, the total ratio of expansion being about 125 fold, as compared with 8 to 16 fold in triple-expansion reciprocating engines. At the ordinary steaming-speed of the *Queen* the revolutions of the centre shaft are about 700, and of the two side shafts about 500 per minute. This high rotative velocity implies the adoption of propellers of small diameter, and the utmost care is exercised in balancing them so as to obtain the full advantage of the absence of vibration obtained by the adoption of the turbine principle.

When going full-speed-ahead all the lines of shafting, central as well as side, are in action, but when coming alongside a quay, or manœuvring in or out of harbour, the outer shafts only are used, thus giving the vessel all the turning and manœuvring-efficiency of a twin-screw steamer. The means for obtaining this manœuvring-power demands a word or two of explanation. Inside the exhaust-end of each low-pressure turbine-cylinder is placed an astern-turbine, controlled by slide-valves, operated by combined steam and hydraulic reversing-engines. These valves admit steam directly into the low-pressure turbines, or into the reversing-turbines within the same. The centre turbine under these circumstances revolves idly in a vacuum, its steam admission-valve being closed, and its connection with the low-pressure turbines being closed by non-return valves. The centrifugal circulating pumps and the air-pumps, all of which are in duplicate, one set for each of the two condensers, are driven by independent double-cylinder steam-engines, and the feed-water is supplied to the boilers by two of Weir's feed-pumps controlled by a float-tank, into which the air-pumps discharge the condensed water. There are also special pumps for wash-deck and fire-service, as also the various pumps for oil and water circulation as required by Parsons' system.

Steam is supplied to the turbines by two double and two single-ended boilers of the Scotch cylindrical type, constructed by Messrs. Denny & Co., the working-pressure being 150 lbs. One noteworthy feature on board the *Queen* will be the absence of the hot cinders and dust, which are, and more especially to ladies, such a nuisance on board most steamers fitted with forced draught. The funnels of the latest of the Dover-Calais steamers are fitted with the Denny & Brace Spark Arrester, by the use of which the decks can be kept as clean as those of a yacht.

The adoption of the Parsons' turbine principle of propulsion for high-speed

vessels, not only gives a substantial increase of speed, but also, by its freedom from reciprocating parts, completely obviates those troubles caused by vibration which have been so annoying to those whose fortune it has been to travel on board of the flying vessels demanded by the modern voyager.

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King Edward VII. Bridge over the River Thames at Kew.

PRIOR to 1757 the only communication across the river Thames between the counties of Middlesex and Surrey from Brentwood to Kew was by means of a ferry, but in that year an Act of Parliament was obtained by one Robert Tunstall—the then owner of the Ferry—for the construction of a bridge, with power to levy tolls for its use by the public.

Owing, however, to objections being raised that the bridge, if built on the site proposed, would interfere with the navigation of the river, the powers were withdrawn, and a second Act was obtained, authorising the construction of a bridge in a more convenient position, and defining the number of the openings to be provided.

The main portion of this bridge was constructed of wood. It had eleven openings, seven of which were composed of timber-framed arches supported on timber pile piers, and four smaller arches, two on each side of the river, of masonry. The centre span was 50 ft. wide, and the six remaining timber arches were 43 ft., 40 ft., and 32 ft. wide on either side respectively. The breadth of the roadway was 20 ft., and the gradient of the approaches 1 in 14.

The six timber piers were each composed of 18 oak piles driven into the river bed, and the flooring of the bridge was made of planking upon which the road metalling was laid.

The bridge was designed by and constructed under the supervision of John Barnard. The work was commenced in 1758, and completed in 1759. It remained in use for nearly thirty years, when in 1782 an Act was obtained by Robert Tunstall, son of the previous owner, for the construction of a stone bridge to replace it.

This second bridge, which has recently been removed, consisted of seven segmental arches of masonry, with Purbeck stone spandril facing and Portland stone parapets. The piers were built of brick-

VIEW OF THE NEW KEW BRIDGE.

From a drawing in the possession of C. A. Brereton, Esq., M.Inst.C.E.

work, faced with stone, and founded upon timber platforms sunk into the river bed. The centre arch had a span of 66 ft. 6 ins, and the side openings were 55 ft. 6 ins., 45 ft., and 39 ft. respectively. The piers on either side of the centre arch were 11 ft. thick, and the others 9 ft. 3 ins. and 7 ft. 10 ins. respectively. The width of the bridge was only 24 ft. 6 ins., the roadway being 18 ft., with footways on either side 3 ft. 3 ins. wide. The gradients of the roadway over the bridge were 1 in 15 on the Middlesex side and 1 in 17 on the Surrey side.

Elliott & Fry.]

SIR JOHN WOLFE BARRY, K.C.B.

The work was designed by, and carried out under the superintendence of, Mr. James Paine. It was commenced in 1783, and finished in 1789. Some years afterwards it was sold to Mr. C. Robinson, and remained a toll-bridge until 1873, when it was purchased and made free to the public, being maintained jointly by the counties of Middlesex and Surrey.

In 1892, owing to the large increase in the traffic, the engineers, Sir John Wolfe Barry and Mr. C. A. Brereton, were instructed to examine the structure and report on the advisability of widening and otherwise improving it. On investigation, however, it was ascertained that the foundations of the piers were not in a satisfactory condition, and, moreover, that it would be impracticable to attempt to improve the gradients. They, therefore, recommended the entire reconstruction of the bridge, either in stone or in steel; and after carefully considering all the circumstances of the case, and having regard to the cost of maintenance, the Councils decided to adopt the former, and obtained an Act of Parliament in 1898 for its construction.

This third bridge consists of three elliptical arches, the centre one being 133 ft. span, with a headway of 20 ft. above Trinity high water, and the two side openings being 116 ft. 6 ins. span, with a headway of 17 ft. The two piers are each 18 ft. thick at the level of the springing of the arches, increasing to 38 ft. at the foundations, which are carried down into the solid London clay at a depth of 18 ft. below the bed of the river. The navigable waterway of the river is 366 ft., or nearly 20 ft. more than that of the last bridge, and over 80 ft. more than that of the original timber structure.

The width of the carriage-way over the bridge and its approaches is 36 ft., and the footways on either side are 9 ft. 6 ins. wide; making a total width of 55 ft. between the parapets, and 57 ft. 9 ins. from

outside to outside of the bridge. The width of the footways on the approaches is increased to 11 ft. The gradient of the roadway over the bridge and approaches is 1 in 40.

The foundations of the piers and abutments are laid with cement concrete, protected by whole timber sheet piling tongued and grooved, and at a sufficient depth to be out of the reach of scour, and also to admit of the bed of the river being hereafter deepened so as to give a navigable depth of 25 ft. below Trinity high water, if required.

The whole of the arches and the exterior of the piers, abutments, and other portions of the bridge, and of the retaining walls of the approaches is of solid granite, obtained mainly from Cornwall and Aberdeen, some of the larger stones weighing as much as 8 tons each.

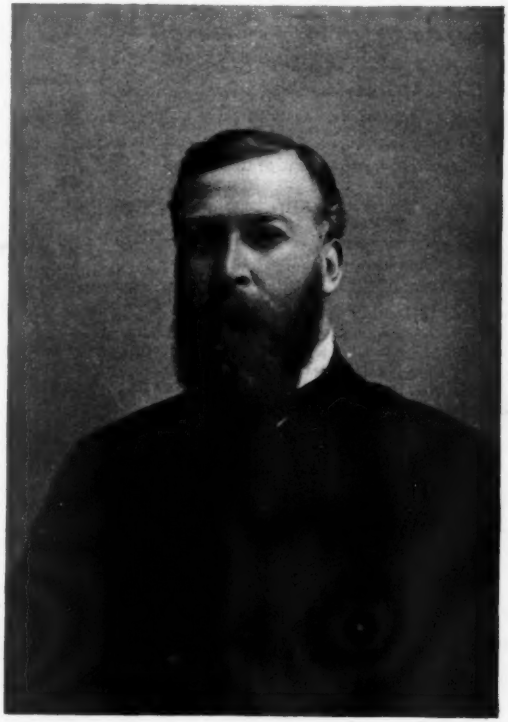
Prior to the removal of the old structure, a temporary bridge was provided on the west, or up-stream side, having openings of 75 ft., 50 ft., and 40 ft. for the navigation.

After the removal of the old bridge, the piers and abutments were proceeded with, and the iron centres for the permanent stone arches were put in position. The masonry of the arches was commenced in May, 1902, and completed December of that year. The internal spandril work for carrying the roadway over the arches was then built, and the concrete and wood blocks for the road, and the pavement for the footways laid. The total length of the bridge is 502 ft. The approaches on the Middlesex and Surrey sides are 270 ft. and 410 ft. respectively, making a total length of 1,182 ft.

The bridge has a handsome and graceful appearance, which has been obtained by a due consideration of proportion and architectural effect, rather than by expensive ornament.

It has taken only about three and a-half years to construct, twelve months having been occupied previously in constructing the temporary bridge and removing the old one.

In our next issue we shall publish further details of this interesting structure, together with the full drawings.



MR. CUTHBERT A. BRERETON, M.INST.C.E.

The engineers of the bridge are Sir John Wolfe Barry, K.C.B., and Cuthbert A. Brereton, Esq., M.Inst.C.E., their resident engineers being Mr. R. W. Dana, A.M.I.C.E., and Mr. W. G. Wales, A.M.I.C.E. The contractors are Messrs. Easton, Gibb & Son, of London, who have so successfully carried out the work.

ENGINEERING ABSTRACTS.

LIST OF PUBLICATIONS REGULARLY REVIEWED.

Amer. Engin. & Rlrd. Jnl.	American Engineer and Railroad Journal	NEW YORK.....	20 *cts.*
Amer. Machst.	American Machinist	NEW YORK	-/4
Amer. Macky.	American Machinery	NEW YORK	-/4
Ann. Ing. Gand	Annales de l'Association des Ingénieurs de Gand	BRUSSELS	*f.*2.50
Brit. Archt.	The British Architect	LONDON	-/4
Brit. Claywkr.	The British Clay-worker	LONDON	-/6
Builder	The Builder	LONDON	-/4
Bldrs.' Jnl.	Builders' Journal and Architectural Record	LONDON	-/2
Bldng. News ...	Building News	LONDON	-/4
Canad. Imp. Trade	Canadian Implement Trade	.....	..
Canad Mfr. ...	Canadian Manufacturer	TORONTO	...
Coll. Gdn.	The Colliery Guardian	LONDON	-/5
Coll. Jnl.	The Colliery Journal and Mining Engineer	LONDON	-/6
Com. Intel......	Commercial Intelligence	LONDON	-/3
Compt. Rendu Soc. Ing. Civ.	Compte Rendu des Travaux de la Societe des Ingenieurs Civils de France	PARIS	. 3.00
Contract Jnl.	The Contract Journal	LONDON	-/6
Echo des Mines et Metall.	L'Echo des Mines et de la Metallurgie	PARIS	p.a. *f.*45.00
Elec. Eng.	The Electrical Engineer	LONDON	s.c. -/3 p.a. 13/-
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Elec. Rev., N.Y.	The Electrical Review, N.Y.	NEW YORK.....	s.c. 10 *cts.* p.a.$5
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Elec. Wld.	Electrical World & Engineer	NEW YORK... ..	s.c. 10 *cts.* p.a.$6
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Engineer	The Engineer..... ..	LONDON	s.c. -/6½ p.a. 29/-
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Eng. Gaz.	The Engineer's Gazette	LONDON	-/6
Eng Mag.	The Engineering Magazine	NEW YORK & LONDON	1/-
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Jnl. Assoc. Eng. Soc.	Journal of the Association of Engineering Societies	PHILADELPHIA, U.S.A.	...
Jnl. Franklin Inst.	Journal of the Franklin Institute	PHILADELPHIA, U.S.A.	30 *cts.*

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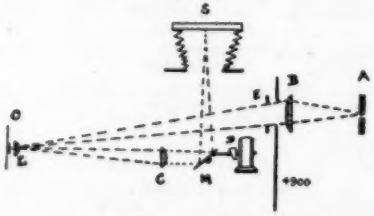
MATERIALS AND MEASUREMENTS.

Modification of Existing System of Units.

The author studies the means of freeing the formulæ used in electricity from certain troublesome factors, viz., the factors 60 and 60×60, depending on the division of time, the factor 75, as occurring between kg.m. per second and h.p., the acceleration of gravity and the factors 10^1, 10^8, 10^9, 10^9, etc., representing the ratios of the practical and c.g.s.-units. The author does not think it fit to adopt the velocity of light as unit of time, as the advantage of invariability claimed for it is illusory on account of the difficulties attendant on measurements of that quantity. It is suggested maintaining the hour and dividing it into 100 minutes of 100 seconds each; the circle should similarly be divided into 24 degrees of 100 minutes each, the latter having each 100 seconds. The factor 75, as used between kg.m. per second and h.p., or between k.w. and h.p., is an arbitrary one, the existence of which is due only to the fact that the unit of power was adopted previously to the creation of an electrical science; in the case of a new time unit being adopted, there would be no reason why a unit of power different from the electrical unit should be chosen. It is next suggested to adopt the bi-dimensional $c\sigma$ system (σ being the centesimal second, as above stated), as well as to organise a universal scrutiny of electrical engineers as to the best means of solving the problem of practical units.—**Dr. Gino Dompieri,** *Zeitschrift für Elektrotechnik, Vol. XXI., No 10,* pp. 137–141, 1903.—*A. G.*

The Blondel Oscillograph.

AMONG the practical uses of this apparatus is the taking of curves of alternators, motors and transformers in studies of design and operation. The arrangement is such that two different wave forms may be taken at a time, corresponding, for instance, to e.m.f. and current, and these are superposed in their relative position. The waves are thrown on a ground-glass screen about 4 by 6 ins. and are traced by a spot of light. For the accomplishment of this a small iron piece is free to oscillate between the poles of a horseshoe magnet and carries a small mirror. The coil carrying the current acts upon the mirror and the latter vibrates according to the variations of the current. The small mirror sends a beam of light on to an inclined mirror, which is oscillated by a synchronous motor, and the combined action traces the wave form upon the screen, as will be seen by Fig. 3. In order to respond exactly to a wave form of a high-frequency period, it is essential that the mirror should follow the variation of the wave at every point, and the vibration period of the mirror itself must be reduced to a minimum in order that its vibrations will not conflict with the impulses it receives from the current. M. Blondel has succeeded in carrying this out by using a very narrow and thin iron band for the vibrating piece, which is stretched between two bridge-pieces, and carries a small and light mirror in the centre. In this way he obtains a band whose rate of vibration is as high as 50,000 periods per second, and can thus follow the variations of even the most irregular waves. The iron band is made as small as possible, and is now only 0·03 in. wide and 0·002 thick; the mirror which it carries is correspondingly small, being 0·01 in. wide, 0·02 high, and from 0·005 to 0·003 thick. It is made of thin glass or mica, which is silvered by deposition from a bath and is attached to the band by shellac. **Henry Hale,** *Elec. Wld., May 2, 1903, Vol. XLI., No. 18,* pp. 743–744.



THE BLONDEL OSCILLOGRAPH.

A	Source of Light.	*K*	Electrically-worked Shutter.
B	Lens.	*O*	Oscillograph Mirror.
C	Lens.	*M*	Oscillating Mirror.
D	Cam on Motor shaft.	*S*	Ground Glass Screen.

Mica.

THE micas are silicates of alumina, the alkalies and magnesia, in varying proportions, which affect their physical properties and commercial value. By far the greater part of the mica brought on to the market is used for electrical purposes in the construction of dynamos, alternators, transformers, and other apparatus. Owing to its elasticity, even thickness, and high insulating properties, mica surpasses all the artificial materials prepared from either animal or vegetable substances. For electrical work it is specially necessary that the mica should be free from cracks, flaws, or specks, for these are a cause of imperfect insulation. The mica strips placed between commutator segments must be of soft quality, in order that they may wear down evenly with the copper. For this particular work soft homogeneous amber mica is chosen, and

when split up into sheets $\frac{1}{32}$ in. thick, it will wear down at the same rate as the hard drawn copper segments. If the mica is too hard the brushes wear the copper down quicker than the mica, and, on the other hand, if the mica is too soft it powders away rapidly, and the commutator segments stand up above the pieces of mica between them. Both these conditions lead to sparking, which becomes worse and worse as time goes on unless the commutator surface is kept constantly trued up. For commutators up to 7 to 9 ins. in length the mica segments are in whole pieces; but for longer commutators whole strips would be so expensive that it is usual to build them up of several thin layers arranged so as to break joint, and making the total thickness $\frac{1}{32}$ in.—**H. Kilburn Scott,** *Trans. Inst. Mining & Metall., Vol. XI., 1902—3.*

The Mechanical Equivalent of Heat.

THE best and most authoritative summaries of the numerous experimental determinations of this constant are unquestionably those contained in two reports to the International Physical Congress of 1900, which met in Paris (Rapports; Congrès Internationale de Physique, 1900, tome 1; see chiefly pp. 204 and 226). One of these is on the mechanical equivalent of heat, by Prof. J. S. Ames, of Johns Hopkins University, and the other on the specific heat of water, by Prof. E. H. Griffiths, of Cambridge, England. The specific heat of water and the mechanical equivalent of heat are the same constant in different terms, the former being merely the value of the latter in absolute units. Griffiths, in his report, after a careful comparison of the best determinations, recommends the number 4·187 joules for what is usually termed the specific heat of 1 gram of water raised from 15 degs. to 16 degs. Cent., measured on the hydrogen scale of the International Bureau. The probable error is less than 1 in 2000. This change in temperature is to be considered the same as the mean value between 1 deg. and 100 degs. Cent. This value, 4·187, agrees with the one recommended in the report of Ames. These two summaries are authoritative and to some extent official, as they are in the form of reports to an international congress. That congress took no action toward adopting any definite value; but a value approximating much more closely to the most probable one than the one in general use does is easily obtained from these reports. Taking for the value of gravity at sea-level and at 45 degs. latitude, as 9·805966 m., a standard value given by Helmert and used by our Coast Survey, the value of the mechanical equivalent reduces to 426·985 kg.-m. Some recent, very carefully made researches by Barnes, which were not finished in time to be included in Griffiths' report, give the value 426·6. The allowable error in Griffiths' value affects the fourth figure, and it is therefore hardly justified to retain more than four figures, but in view of Barnes' more recent determination, it would probably be more correct to abbreviate Griffiths' value to 426·9 instead of 427·0. This value 426·9 kg.-m. per kg., Cent. heat unit, corresponds to 778·1 ft.-lbs. per lb. Fahr. heat unit, which two values may, it seems, be accepted as the best determinations known to-day.—**Carl Hering,** *Proc. Engrs. Club, Philadelphia, Vol. XX., No. 1,* pp. 115-6.

Hard and Mild Ingot-Irons as Materials of Construction.

MILD ingot-iron is generally considered by mining engineers as a better material of construction than the harder sorts, as the greater resistance of the latter is greatly impaired by the unfavourable influence exerted upon them by treatment. As, however, recent practice shows a marked preference for higher strengths, the author tries to ascertain whether these higher strengths are really of so high a value. These researches are particularly difficult on account of the numerous branches of engineering they embrace, some of which are not very familiar to mining engineers; but especially on account of the delicate scientific apparatus required to observe and to measure the smallest molecular motions of iron. In order to obtain an adequate idea of the relations existing between strength and limit of elasticity, upwards of 700 tests have been made with specimens derived from five different works. All these specimens had a tearing-length of 200 m. and 40 mm. in breadth. The limit of elasticity would be determined by increasing the load from 2 kg. to 3 kg., and measuring the tensions corresponding with these loads on a length of 100 mm. After rupture the tensions would be ascertained on a length of 200 m., the limit of elasticity being determined by means of the Martens-Kennedy apparatus. These tests go to show that the limit of elasticity increases and decreases by no means in the same ratio as the strength, the ratio of the former to the latter decreasing with increasing strength. This ratio is, moreover, greatly influenced by all modes of treatment, the rate of decrease being higher for hard ingot-iron than for the milder sorts. From this it may be inferred that the advantage of high strength is less than was hitherto supposed, a construction of hard material, as calculated with the same percentage of strength as another of mild material, affording less safety

than the latter. Mild materials are liable to heavier specific strains than hard ones.—**F. R. Eichhoff,** *Stahl und Eisen, April 15, 1903,* pp. 489.—*A.G.*

CONSTRUCTIONAL.

The Effect of Design on Methods of Construction.

WHEN speaking of design, we are apt to think of drawings only, whereas, the specification, the quantities, and more especially, the instruction of the engineer as the work proceeds, govern to a very great extent, the methods which the contractor has to adopt in carrying out the work in the most economical manner. While the drawings show the work as it will appear when completed, and the specification gives in somewhat general terms the methods which will have to be adopted in constructing the works, these may, as the work proceeds, be modified almost out of recognition by variations, made and covered by clauses in the specification which give the engineer power to vary, increase, or decrease, while adhering to the prices tendered. From this cause arise difficulties, delays, etc., ending often in claims, which create friction and annoyance, for which the contractor cannot justly be held responsible. The author shows how, by various small differences in design, the cost of construction may vary over a very wide range. Among the examples selected are some relating to the construction of reservoirs, retaining walls, arches, and to the laying of water and gas mains. In conclusion the author appeals to all engineers to give their juniors the fullest opportunities of seeing work under construction, feeling sure that time so spent will afford the best education of a practical nature that the junior engineer can have.—**R. W. Newman,** *Proc. Jr. Inst. E., April, 1903.*

Curves of Maximum Bending Moment.

IN order to simplify the calculations of flange areas in plate girder bridges of short or moderate span, it is not unusual to assume that the stresses produced by the moving load are equal to those produced by a uniformly distributed load. This assumption is very convenient, but leads to waste of steel, and it is suggested that railway companies would save money by setting aside the uniformly distributed load system and employing an engineer specially to plot the actual curves of maximum bending moment for all spans from 5 ft. to 100 ft. These curves, though not so simple as the parabola of the uniformly distributed load, may still be readily obtained in the manner described in detail by the writer. To the curve of maximum bending moment for the moving load may be added an allowance for shocks and stresses to which the bridge will be subjected by the kinetic force of the moving load and by the vibration of the girders. The not uncommon practice of adding a percentage to cover these contingencies gives a large increase of flange area at the centre of the span, and practically none at the abutments, where shocks are quite as common and as severe. The whole subject of allowance for subsidiary stresses is very involved, and the contingencies enumerated by the author do not readily lend themselves to mathematical treatment. It is better that the engineer should determine the allowance for himself after taking into consideration the class of locomotives running over his bridges, than that the matter should be left to the draughtsman.—**A. L. Bell,** *Engineer, May 8, 1903,* pp. 469—470.

METALLURGY.

Potassium Cyanide and Nitrogen Reactions with Blast Furnace Processes.

IN the course of the last ten years, it has been observed with several blast furnaces that the manufactured cast-iron, though the best material be used and all possible care taken in forging, would yield unsuitable metal in the Lancashire-hearth, the iron produced in the latter being brittle even at a red and yellow heat. This property cannot be detected by the current methods of analysis, nor does the appearance of such iron show any peculiarity. Different explications of this remarkable behaviour have been suggested, many observers ascribing it to a lower percentage of carbon. The author thinks that it is rather due to the presence of nitrogen, the more so as, no easy method of analysis being forthcoming for this metalloid, its presence has so far been practically neglected in the metallurgy of iron. Now, an analysis of the gases contained in the blast shows that they are a mixture of nitrogen, hydrogen and carbon monoxide; as the latter two are known as to their actions on the iron, it is highly probable that the former should impart to the iron the above property. Further evidence of the fact that nitrogen is far from being the indifferent substance it has been taken for is shown by the potassium cyanide deposited in the case of an enforced operation. Iron and free nitrogen at any temperature will, according to the statements of many experimenters, be perfectly indifferent against one another. If, however, the nitrogen be combined with other substances, such as hydrogen or carbon, instead of this neutral state, there will be produced chemical compounds

of iron and nitrogen, the composition of which has been determined by Frémy as Fe_3N and by Stahlschmidt as Fe_4N. The author studies the conditions under which iron will absorb nitrogen, this being the case, for example, in the presence of either ammonia or cyanides. It is shown that nitrogen will impart to iron hardness and brittleness, both in the cold and the hot state. By heating in atmospheric air the nitrogen is readily driven off, but never completely, as small quantities are always found to remain, preventing the iron from recovering its original properties. Even melting with oxidation has proved little efficient. As nitrogen, once absorbed by the iron, thus cannot be driven off by any subsequent treatment, without spoiling the quality of the metal, the author thinks to be warranted in maintaining that nitrogen is the most dangerous gas to iron. It is next shown that the enforced treatment of Lancashire cast-iron is particularly favourable to the absorption of nitrogen. The author's investigation into the noxious influence of nitrogen on iron is based on practical experience in connection with existing chemical analyses. Further evidence may be derived from the theoretical fact that nitrogen in Mendeleieff's natural system belongs to a group including phosphorus, vanadium, arsenic, niobium, antimony, didymium, tantalum and bismuth, the latter being the least negative; as the other constituents of this group are the more noxious, as they are more negative, nitrogen is likely to be the most noxious.—**Hj. Braune.** *Teknisk Tidskrift, XXXIII., Section for Chem., etc., No. 4,* pp. 45–49, *April 25th, 1903.—A. G.*

Action of Carbon, Carbon Monoxide and Carbonic Acid on Iron and its Oxides.

THE processes occurring in the blast furnace and resulting in the reduction of the ores are still insufficiently known, in spite of the great bearing this question has upon practice. As the reduction of ferric oxide by carbon oxide has been investigated by Breithwaite (the result being that at a dark red an excess of ferric oxide will convert the whole of the carbon monoxide into carbonic acid), the authors investigate the two remaining processes, viz.:

$$(I.)\quad FeO + CO \rightleftharpoons Fe + CO_2$$

$$(II.)\quad Fe_3O_4 + CO \rightleftharpoons 3FeO + CO_2$$

The ratios of concentration, $\frac{CO}{CO_2}$, being in equilibrium at different temperatures with FeO and Fe, or with Fe_3O_4 and FeO, have been determined with an apparatus made up of a porcelain tube closed at one end and surrounded by a coil of thin platinum wire, through which a heating current was sent. This tube contained a tray charged with a mixture of either FeO and Fe_3O_4 or Fe and FeO. Treating this alternately with carbon monoxide and dioxide at the same temperature and analysing the gas at regular intervals, the composition of the gas, being at this temperature in equilibrium with the mixture, would be ascertained. Curves representing the results for a range of temperatures from 330 degs. to 990degs. are given and combined with Boudonard's curve for the equilibrium,

$$2CO \rightleftharpoons CO_2 + C.$$

The following practical conclusions are drawn from a discussion of the results. The presence of pulverulent carbon, liable to disturb in a most troublesome way the operations of the blast furnace, is possible only below 685 degs., as beyond this temperature the reaction is represented by

$$FeO + C \longrightarrow Fe + CO,$$

it will be avoided by increasing the temperature. It is next shown that F_3O_4 is least reducible at 500 degs., and that FeO is most readily reduced at a temperature of about 700 degs. The data given by previous investigators are finally recorded, it being shown that some seeming contradictions may easily be accounted for on the results of these experiments.—**E. Baur** and **A. Glaessner,** *Stahl und Eisen, Vol. XXIII., No. 9,* pp. 556–562, May 1, 1903.—*A. G.*

IRON AND STEEL.

Allotropic Changes of Iron and its Alloys.

THE research work presented consists of an nvestigation of variations in the electric resistance of iron and steel, with the object of determining allotropic changes. The results obtained establish the perfect reversibility of the phenomena of the electric resistance of iron and its alloys in functions of the temperature, at least for those temperatures outside the zones in which the allotropic changes occur. In the neighbourhood of the critical points the deviation between the heating and cooling curves, in the case of carbon steel, is greater the higher the proportion of carbon. Steels containing foreign metals, such as chromium, manganese, or tungsten, present in general distinctive features of the same type as those noted in the case of steels containing above one per cent. of carbon. The curve of the variations of electric resistance of irons and steels does not alter

its parabolic form between the ordinary temperature and that at which the transformations begin to occur. But from 800 degs. onward they become linear. The following equations represent the phenomena above the temperature of 800 degs. :—

Steel with 0·205 % carbon...	$R=42·8+0·0486t$
,, ,, 0·493 ,, ...	$R=47·0+0·043t$
,, ,, 0·841 ,, ...	$R=72·7+0·023t$
,, ,, 0·82 ,, ...	$R=92·9+0·028t$
,, ,, 1·05 ,, ...	$R=92·0+0·029t$
,, ,, 1·16 ,, ...	$R=90·6+0·0283t$
,, ,, 1·38 ,, ...	$R=97·75+0·0301t$
Chrome steel, C1 ...	$R=74·2+0·031t$
,, ,, C2	$R=67·55+0·017t$
,, ,, C3	$R=67·3+0·0255$
Tungsten steel, V1... ...	$R=67·8+0·015t$
,, ,, V2	$R=59·0+0·032t$
,, ,, V3... ...	$R=66·4+0·0183t$
Manganese steel, M2 ...	$R=92·8+0·0226t$
,, ,, M3 ...	$R=84·9+0·033t$
Nickel steel, N1	$R=116·7+0·045t$
,, ,, N2	$R=125·7+0·035t$
,, ,, N3	$R=118·0+0·047t$

In the case of the specimen of iron investigated by the author, the three following linear equations represent the phenomenon:—

From 655° to 775° ...	$R=-51·9+0·189t$
,, 781° ,, 877° ...	$R=39·3+0·071t$
,, 896° ,, 1170° ...	$R=74·4+0·031t$

In the case of carbon steels the electric resistance increases with the carbon content. The addition of chromium and of tungsten increases the resistance sensibly in the ratio of 1 to 2. But this ratio of increase is not maintained at high temperatures, at which point the chrome and tungsten steels have a degree of resistance about equal to that of carbon steels. Manganese at ordinary temperatures causes the resistance to become at least two or three times greater. Nickel produces a much greater increase in the resistance than manganese. In the case of both of these metals the ratio of increase is much less in the hot state than in the cold state.—**O. Boudouard,** *Trans. Iron and Steel Inst., May, 1903.*

The Influence of Sulphur and Manganese on Steel.

THE present paper relating to a series of investigations in the micrographic laboratory of Sheffield University College, is an instalment covering only a small portion of the ground, but that part is perhaps the most interesting, because it clears up mechanical phenomena due to the micro-chemical relations of carbon, manganese, and sulphur in steel. — **Professor J. O. Arnold and G. B. Waterhouse,** *Trans. Iron and Steel Inst., May, 1903.*

The Thermal Efficiency of Hot-Blast Stoves.

THE present paper is the result of an attempt to weigh the hot-blast stove in the balance of efficiency independently of the structural characteristics adopted by different makers, the investigation being applied to determine whether it is possible with a given heating capacity to raise the efficiency to the maximum practical, and sustain it as near to that possessed by any well-designed recuperator of a gas-fired open-hearth furnace. The author says that ironmasters should see that in the development of public electric power transmission schemes, the dynamic power potential of their blast-furnaces is not overlooked by the promoters. It is almost of national importance that our blast-furnaces be kept in continuous operation, and it is quite possible that the auxiliary profit to iron-making that would be obtained from the generation of electrical energy would go far towards enabling this desirable continuity of iron-making operation to be maintained. —**B. H. Thwaite,** *Trans. Iron and Steel Inst., May, 1903.*

The Alleged Cementation of Iron by Silicon.

RESEARCHES by the writer do not disprove Mr. Lebean's observations that solid iron in practically a molecular state of sub-division combines with solid silicon at about 1,000 degs. Cent. They do show, however, that at temperatures between 1,100 degs. Cent. and 1,200 degs. Cent. solid iron and free silicon do not combine, and that cementation by silicon is impossible when the iron and steel operated upon are in solid masses.—**J. E. Stead,** *Trans. Iron and Steel Inst., May, 1903.*

The Open-Hearth Process.

IN this paper the author undertakes a complete study of the balance of the furnace, of the temperatures, of the oxygen in the bath, etc., and gives results obtained from experiments conducted with a Tourton New Form Siemens furnace.—**Leut.-Col. Leandra Cubillo,** *Trans. Iron and Steel Inst., May, 1903.*

PRIME MOVERS.

Pressures Occurring with Explosions of Hydrogen and Carbon Oxide in Closed Vessels.

THE principles underlying calorimetrical tests of combustion-motors are but insufficiently known. A relation between the specific heats of gases and the temperature is suggested by the experiments of Mallard and Le Châtelier ; on the other hand, there are most divergent opinions as to a possible dissocia-

tion of aqueous vapour and carbon dioxide. A thermodynamical analysis of experiments on gas engines, analogous to the one carried out by Hirn and his disciples for the case of the steam engine, has been derived by Slaby from the experimental results of Mallard and Le Châtelier. As, however, the reliability of these results has been doubted, the author has undertaken to repeat the experiments. It is inferred, from a comparative study of the results of previous observers that, calculating the pressures of explosion on the hypothesis of constant specific heats and perfect combustion, values far exceeding those observed are arrived at. As for the same experimenter, the kind of inert biatomic gases does not exert any influence on the pressures of explosion, the quantities being the same, the molecular heats of biatomic gases must be identical even for temperatures as high as 2,500 degs. The pressures observed by the author are generally identical with the values found by Mallard and Le Châtelier. The following conclusions may be derived from the results of the author:—The diagrams representative of explosions will show marked discontinuities, if the bomb contains carbonic acid for explosive temperatures exceeding 1,700 degs. The dissociation of carbonic acid thus begins at this temperature. In the case of hydrogen being alone present, the cooling subsequent to complete combustion will, however, occur in a perfectly regular way. The range of dissociation of aqueous vapour seems thus to lie beyond the limits of the experiments. Assuming the thermical increase of the mean molecular heats to be linear, the following formulæ will correspond to the pressures of explosion observed, with an accuracy sufficient for technical applications:—

Simple gases: $C_0 = 4,8 + 0,0005\,t$
Aqueous vapour: $C_0 = 5,9 + 0,00215\,t$
Carbonic acid: $C_0 = 6,7 + 0,0260\,t$,

where C_0 are the molecular heats. The two latter formulæ give values increasing more rapidly than according to Mallard and Le Châtelier's formulæ. — **Dr. Arnold Langen.** *Zeitschrift des Vereins Deutscher Ingenieure, XXXXVII., No. 18*, pp. 622-632, *May 2nd, 1903.—A. G.*

Seamless Steam Boilers.

AFTER having explained fully the Ehrhardt process for making seamless tubes from a full square block, the writer describes the application of the process to the rolling out of a heavy tube into a boiler body. Mr. Ehrhardt uses a rolling mill with two rollers, of which the top roller takes the hollow block and the bottom one swivels in rolling. The hollow block is made of such a diameter that it goes easily over the top roller; the bottom of the blank is cut off so that a cylinder of the finished length remains. The rolling out to the proper thickness and diameter is done on the rolling mill, which has a very powerful engine. The bottom roller is arranged to swivel right and left (Fig. 1) around the centre-point *A*, and is pressed upward by hydraulic pressure, so that the same pressure is always acting. For facilitating the rolling out and reducing the pressure upon the rollers, the bottom roller oscillates during its work as shown in Fig. 1. In the inclined position the pressure is exerted only in the middle at *A*, and spreads gradually from the middle position until it covers the whole length of the rollers. As rollers always bend somewhat, this oscillating movement ensures uniform thickness of the cylinder. It is not thicker in the middle, as is usual with rolled plates. For guiding the rolled cylinder side rollers are used, which give a steady run to the cylinder. These side rollers are arranged so that they are fixed by a lever corresponding to the diameter of the boiler-barrel to be produced. A boiler-barrel made in this way possesses in all its parts an equal resistance, and is far superior to a welded or riveted barrel. The press and rolling mill of Mr. Ehrhardt at Düsseldorf-Reisholz produces boiler-barrels for locomotives and marine from 1 to 5 metres (3·28 to 16·4 ft.) diameter, cylinders for hydraulic presses and accumulators, and all other kinds of hollow bodies of great resistance for great pressures. Locomotive and marine boilers made with seamless barrels, according to Ehrhardt's

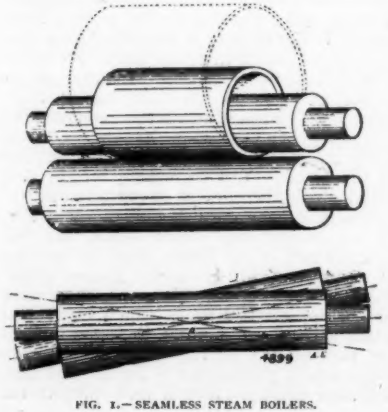


FIG. 1.—SEAMLESS STEAM BOILERS.

process are lighter and of greater resistance, durability, and tightness than those made according to the usual method, with welds and rivets.—**G. Lentz,** *of Düsseldorf, Am. Eng. and Rlrd. Jnl. May, 1903,* pp. 191–192.

TRACTION.

Freight and Express on Electric Railways.

OF the many strictly interurban electric roads in the United States over 50 per cent. do a regular express and freight business, while over 25 per cent. of the remainder carry packages, express or freight to a greater or lesser extent. Almost without exception this business is not only a very remunerative part of their operating, but it grows in volume and scope in a way that leaves the purely passenger business far behind. This business and this growth has been not only in the face of bitter opposition from without but it has had to contend with ignorance from within. With a view of obtaining information as to local classification and traffic, enquiries were addressed by the writer to 147 separate electric roads, and answers were received from 129 of them. From these it appears that out of 37 of the largest freight carrying electric roads in the country, eighteen use the standard steam road classification and local distance tariff absolutely, while eleven "base" their rates on the same. The remainng eight roads, which do not use steam road classification or rates either as a standard or a basis, have rates which are as irregular and arbitrary as the average of the express rates. This is probably due to the fact that, as yet, none of them directly compete or connect with any steam road, and their rates have, therefore, been made either in competition with wagon-hauling or they have had local conditions which forced or enabled them to make either very low or very high rates. In the hauling of steam railroad cars over electric roads there are not as yet many electric roads so favourably situated as to grades, curves, and sub-structures on their lines, or by reason of steam road connections that they can do such hauling. These however, are features which will be improved in the future. The increasing weight and speed of electric cars on interurban lines in necessitating the construction of the track, in accordance with strict steam railroad practice will, in the future, allow the hauling of steam road cars to a much greater extent than is now done. Also, the increasing number of electric roads which tap steam roads will greatly increase the opportunities for this branch of the business. Eleven roads report the hauling of steam road cars, but there is quite a lack of uniformity in the method and rate of charging. It will probably be some time before the exact general status of the electric freight and express business will be publicly known, but still, to those who have watched the course of the business closely from the start there is no doubt that these branches of electric railroading are profitable to a very fair degree. Their enormous increase in the past is patent to all, and a single visit to a dozen or so freight and express-carrying electric roads will prove that the future increase in both scope and amount will be much greater than in the past. **H. S. Cooper,** *Street Rly. Jnl., Vol. XXI, No. 7,* pp. 263–6.

Steel Roads.

WHEN the test was made on the steel road in New York of hauling a load by a rope with a spring balance interposed, no account was taken of the grade, and as the comparative traction shown was 100 lbs. on the rails and 160 lbs. on the stone pavement, the advantage was stated at 60 per cent. The grade, however, being 2 per cent., the actual lift in both cases was equal to 2 per cent. of the total load, and as the wagon weighed 3,700 lbs., the lift was 74 lbs. ; this, deducted from the amounts named, 100 and 160, leaves the comparative traction due to rolling and axle friction, that is, the comparative pull on a level, in proportion of 26 to 86. This corresponds closely with the German tests which are reported as varying from 1 to 3 up to 1 to 5 for the comparative traction on steel and other roads. Reduced traction evidently reduces in like proportion the wear and tear on road, vehicle and power, whether animal or mechanical. The durability of the roads may be assumed from this fact, together with some corroborating data from actual experience, which indicate a life of 30 or 40 years or more. The adoption of steel for road construction would not only reduce the expense of hauling far below the European standard, but it would open its own way to provide the means for construction throughout the country. It would practically eliminate the question of repairs for at least a generation, whereas in stone roads the cost of maintenance is most serious, amounting in some cases to 10 or even 15 per cent. of the original cost of the road. Supposing the track metal to cost $2,000 per mile and that the expense of laying is paid by local taxation, the bond issue would only then be $2,000 per mile and the interest only $40 per mile yearly, which is no more than the present cost of keeping a much-travelled earth road in repair. — **General Roy Stone,** *Eng. Rec., Ap. 25, 1903, Vol. XLVII., No. 17,* p. 437.

L. B. and S. C. Railway Improvements.

THE steel arched bridge described in the *Engineer* for March 20th may be regarded as an example equally representative of two other structures erected over Battersea and Prince of Wales' Roads. Where the London, Brighton & South Coast line passes over that of the London and South-Western a bridge of some importance has been built. The abutment on the Victoria side is on an angle of skew of 40 degs. with the axis of the bridge. So also are the piers, but the abutment at the Clapham Junction end is set square under the girder bearings. There are in all seven main girders, of which four are pairs. Two have each a span over end plates of 49ft. 9ins., two a span of 150 ft. between column centres, and the remaining spans are 68 ft. 3 ins., 48 ft. 8 ins., and 46 ft. 8 in. over all. The smaller side span at the Victoria end of the bridge traverses a piece of waste land, but the larger side span is not so simply situated. There are three different levels at this crossing: Russell Street, the L. and S.-W. permanent way, and the bridge under description. The article contails full details as to construction and erection, and is illustrated by reproductions and photographs and working drawings.—*The Engineer, May 15th, 1903*, pp. 488-491.

LIGHTING, HEATING, AND VENTILATION.

The Design and Testing of Centrifugal Fans.

THE present paper is to a certain extent supplementary to one read by Mr. Heenan and the author, before the Institution of Civil Engineers in 1895, but it deals with installations of fans of larger sizes, designed on the principles laid down in the previous paper, and particulars of some tests are also added. Formulæ are given for the output of fans for ordinary purposes, as well as for fans used for induced draught in electric lighting stations and other places.—**W. Gilbert,** *Proc. Civ.-Mech. Eng. Soc., 1903.*

The Economy of Electric Light Equipment in Small Factories.

NUMBER of Lights Required.—A factory of 25,000 sq. ft. of floor space may usually be lighted properly with 200 or 250 sixteen-candle-power lamps or an equivalent number of eight-candle-power lamps, and a factory of 50,000 sq. ft. of floor space may be properly lighted with 400 sixteen-candle-power lamps or an equivalent number of eight-candle-power lamps. The use of eight-candle-power lamps is finding increased favour in factories where the nature of work is such that each operative requires an individual lamp. The writer had recently to design a lighting equipment for a factory in which about 200 bench foot-presses were in use, located about 40 ins. on centres, and an eight-candle-power lamp for each operative was found much more satisfactory than one-half the number of sixteen-candle-power lamps. *Lighting Equipment.*—Belted-type direct-current generators, 125 volts, designed to run at speeds from 600 to 900 revolutions per minute, may be driven from the main line of shaft, being thrown in and out of service by means of a friction clutch. A slate switchboard, mounted in a suitable angle iron framework, and equipped with voltmeter, ammeter, main switch, circuit-breaker, feeder switches, and voltmeter and ground detector switch, is required. The wiring for lights will generally be run exposed on porcelain cleats or knobs, and the majority of the lights will be drop or pendant lights according to the nature of the work carried on in the factory. *Comparison with Cost of Buying Current from a Local Consumer's Company.*—For a consumption of current not exceeding 5,405 kilowatt-hours per year the rate per kilowatt-hour for service from a consumer's company would rarely be less than ten cents per kilowatt-hour. On this basis the comparison is as follows:

Annual Cost with Factory Lighting Equipment.	Annual Charges of a Consumer's Company for Current.	Annual Saving Effected with Factory Lighting Equipment.
300 lights, $257.00	$325.00	$68.00
500 lights, 399.30	540.50	141.20

F. O. Runyon, *Elec. Rev. N.Y., May 16, 1903, Vol. 42, No. 20*, p. 675.

APPLIED ELECTRICITY.

Electric Power for Factories.

IN this paper the author discusses possible developments of electrical driving in factories due to the supply of electricity at cheap rates by large power companies. The intrinsic difference between power distribution companies and ordinary electric supply works is, that the town schemes are started at first to supply light in the central portions of the town, gradually working to the outskirts. To the lighting supply has been added, in manufacturing and other towns, a considerable amount of business in supplying electrical energy for driving motors and similar purposes. In the case of the power distribution schemes, on the other hand, the stations as a rule are to be placed outside large towns and not necessarily near to them, and the supply is to be

given to large works, chiefly for power purposes, and in a secondary way small local authorities are to be supplied in bulk for all the usual purposes for which electrical energy is used. This means that when the power schemes are started on a big scale, the capital outlay on cables is heavy in proportion to the amount of business immediately obtained. It is therefore very necessary, at least in a number of instances, that the power companies should be allowed to use overhead wires in place of underground cables, in order that the capital cost of the distributing system may be kept as low as possible. After pointing out the advantages of public over private power plants, especially in the use of large producer-gas driven engines, the author suggests the economy of water power as a reason for superseding steam for large power supply. The coal fields are also instanced as affording immense opportunities for the new power companies, and although the author admits that supply companies have not been able hitherto to supersede steam engines for cotton mills and other large works, he says it is possible that the gas engine may help the electrical power companies to obtain even loads of this character. When it is remembered that the Newcastle company are already supplying several large works, that the Hull Corporation are supplying about 1,200 h.p. to a big ship-building yard, and that the Sunderland Corporation are laying out great extensions with a similar end in view, there is no reason why, when the power companies offer an adequate and cheap supply of electrical energy, the large works in the area should not follow the lead. One of the great inducements of taking a supply from outside is the saving in capital expenditure of generating plant; the capital so spent can generally be expended in additional manufacturing plant, and many manufacturers are sure to regard this saving as a great advantage. If, in addition, the power companies lay themselves out intelligently to push the use of motors, and to advise with skill on the method of their use, and possibly also to follow the lead of numerous Corporations and to hire out motors, they should find plenty of work for their hands, and so do their share in developing the electrical industry. Further than this, by acting as instructors in the use of electric driving they will indirectly benefit the stations already supplying energy in the big towns. In conclusion, the author considers various systems of charging for power and the effect of these upon the station load.—**J. S. Highfield,** *Manchester Section, Inst.E.E., Paper read, Feb. 17, 1903.*

Electric Plants and Atmospheric Discharges.

AN interesting enquiry was, some time ago, made with all the electric mains of Germany and Austria into the dangers to which electric plants are exposed on the part of atmospheric discharges, it being shown that no absolutely sure safe-guards against disturbances by the latter are forthcoming. With all the types of protective devices mentioned, some parts of the installation are, in fact, liable to being injured; certain types, however, have given better results than others Connecting the objects to be protected with the terminals of re-action coils is to be highly recommended. In some cases of close weather dangerous atmospheric charges may occur in aërial lines, even without any thunderstorm taking place. It is not advisable to connect the earth wires of lightning rods with conduit-pipes instead of with special earth-plates. No conclusions may be drawn from the answers received as to the influence of separate earthing or separate insulating of the iron frames of machines and transformers, or the influence of the nature of the ground.—**Dr. Benischke.** Paper read before the *Elektrotechnischer Verein*, Berlin, May 12th, ; see *Elektrotechnischer Anzeiger*, No. 44, p. 1350, 1903.—A. G.

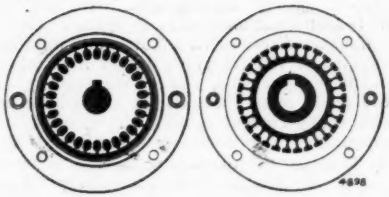
Simultaneous Telegraphing and Telephoning.

A NOVEL system for simultaneous telegraphing and telephoning on the same wire is being discussed by the Italian technical papers. This system has lately been tested on the Rome-Venice telegraph line, the results being highly satisfactory. In the present article the author gives a short description of the apparatus devised by Professor Brunè and Signor Turchi. The problem the two inventors had to solve may be enunciated as follows: "Two alternate currents of different frequencies traversing the same circuit, the effect of either of them should be eliminated." In the actual case there are the telephone current and an induced current due to the telegraph current, both exhibiting an alternating character, but with different frequencies, the effect of the induced current being the one to be annihilated. In order to show how this is possible the author considers a closed circuit, a certain section of which is divided into two branches of equal ohmic resistance, forming a differential coil wound on a soft-iron core. Supposing that the two differential branches have different impedances, it will be understood that with a current of given frequency it is possible to regulate the two impedances, so as to have in the core a resultant flux equal to zero.

If, therefore, two currents of frequencies, a_1 and a_2, be sent through the circuit, the later being, for instance, regulated for the frequency a_1, only the current of frequency a_2 will give a flux different from zero. Now, if the soft-iron core be the one of a telephone, the latter will show the effects only of the frequency a_2, and, generally speaking, of any frequency either superior or inferior to a_1. A similar circuit, capable of compensating the effects on an external circuit of *either* of the currents evolving through it, is termed *separator* by the inventors. The separation, as stated above, is obtained for currents of alternate character In the case of either of them being a telegraph current, the frequency of which may range between rather extensive limits, the other current should have a frequency included between those limits, in order to obtain the separation; otherwise the corresponding telegraphic frequencies would be, as well, eliminated. It may finally be understood that the separator will eliminate not only the effects of a current of a single frequency, but practically those of a certain number of frequencies as well, all of which are very near the *theoretical* frequency producing a perfect compensation. Ordinary telegraphic currents will produce induced currents with frequencies as high as about 200 periods. Now, as the Brunè-Turchi separator is regulated for similar frequencies, if in any circuit induced telephonic currents with frequencies of the above order and telegraphic currents (the frequencies of which, as is known, are much superior to 200 periods) be present at the same time, the separator will annihilate the effects of the former, those of the latter remaining active; in other words, the telegraphic transmission will in no way interfere with the telephonic transmission.—**A. Banti,** *L'Elettricista, Vol. XII., No. 5, May, 1903,* pp. 117-119.—*A. G.*

Manufacturing Armature Discs and Segments.

Discs of large diameters are usually cut plain by shearing the outside circle, and afterwards the inner circles, on circular shearing machines, and notching is done on an automatic notching machine with a plain blanking punch and die at one side, and the circular disc is clamped between the two pads of the indexing and revolving mechanism at the other. The indexing is entirely automatic, the spacing and number of notches in a disc depending on the arrangement of the gearing. Adjustment for different diameters is made simply by turning a hand-wheel. A spring stripper is fitted, making it easy to introduce a new disc, and providing for holding the disc under pressure when the notch is being punched. When polyphase motor discs are notched in a machine of this type, it is necessary to do the notching before the large inner circle is removed, and one or two small holes are previously punched in that portion of them that is afterward cut away, in order to serve as guides in the notching and centre-hole punching. The quickest, most accurate, and most economical way of making discs for street-car motors is to use a press with dies so constructed and arranged that the inside of the disc with its key-slot, and the outside with its notches, are cut simultaneously. The figure shows plans of a compound punch and die. As a rule these dies are used in presses with upper and lower knockouts, thus obviating the necessity of strippers in the dies. The dark parts in the figure indicate the cutting parts. Another method adopted when smaller quantities of discs are required is to cut the plain outside and the hole simultaneously, and then to punch the notches in a press. As by this method the outside notches are cut separately, the power of the press in which the work is done is equal to much larger diameters than those used in the manner before described.—**J.V. Woodforth,** *Machy., May, 1903,* pp. 455-456.



MANUFACTURING ARMATURE DISCS AND SEGMENTS.

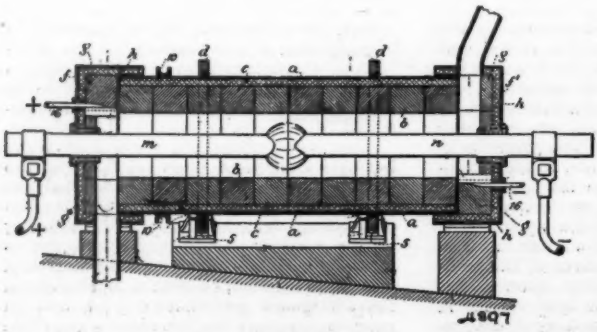
The Storage Battery in Transmission Plants.

The use of the storage battery as a reserve in connection with the exciters of the alternators in large transmission plants is growing to be an important additional safeguard against breakdowns. Normally it will float on the bus-bars while the exciters supply current to the alternator fields, stepping into harness and picking up the load instantly if the exciter voltage fails, in its rôle of "watch dog of the system." Ordinarily an exciter is regarded as a thoroughly reliable and staid piece of machinery, capable of operation on the continuous performance plan, and in many installations the provision for duplicate machines has been considered sufficient pre-

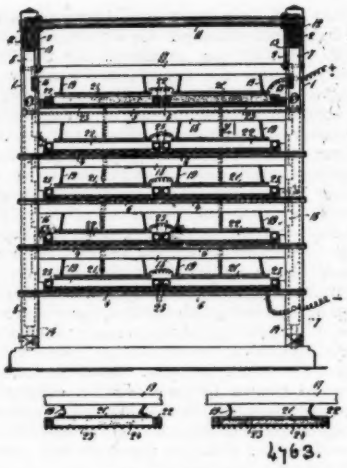
caution against interruption. The battery finds additional usefulness in operating miscellaneous direct-current motors and lighting circuits of the travelling crane and other auxiliary apparatus, and in the starting of the plant when the exciters are driven by alternating-current motors. It also assists materially in preventing or reducing the fluctuations of alternating-current voltage, which are often aggravated by corresponding fluctuations of exciter voltage and current if there is no battery installed.—**H. S. Knowles,** *Elec. Wld. and Eng., May 16, 1903, Vol. XLI., No. 20,* p. 831.

Electric Furnace.

A DEPARTURE from the usual type of electric tube furnace consists in providing within the tube an auxiliary heating means in the form of an arc between carbon terminals. The tube walls are composed of resistance material and are brought to incandescence by the passage of a current in the usual manner. A longitudinal section of the furnace is shown herewith. The tube is constructed of graphite sections, *b*, surrounded by an insulating sheath, *c*, and encased by sheet metal, *a*. This tube is mounted for rotation between stationary caps, *f*, *f*, these caps being lined interiorly like the tube with insulating material and with graphite. The bearings consist of metal rings, *b*, mounted on the tube and turning on rollers, 5, power being applied to the tube through a pulley, 10. The furnace is preferably mounted at an inclination, and the feed and discharge occur through the cap plates. The terminals, 16, 16, of the heating circuit are on the cap plates, and contact is made through the annular graphite blocks, *g*, with the tube revolving in contact with them. The auxiliary heating circuit comprises carbon electrodes, *m*, *n*, introduced through the cap plates, and adjustable therein to form an arc at any desired portion of the furnace.—**C. P. Townsend,** *Elec. Wld., Vol. XLI., No. 20, May 16, 1903,* p. 835.



ELECTRIC FURNACE.



DRYING BY ELECTRICITY.

Drying by Electricity.

THIS method for drying peat and other substances, depends upon the well-known fact that liquids, and particularly liquids of low electrical conductivity, are transported from the anode toward the cathode under the influence of a strong electric current; if the liquid in question is in the form of moisture saturating a non-conductor, the latter may be interposed as a diaphragm between the electrodes, and the effect of the current will then be exerted in forcing the moisture from it, the cathode being preferably perforated to provide for its free discharge. The latest construction is shown herewith in elevation, the uppermost trays or cells appearing in section. Wooden side frames, 1, 2, with appropriate cross-frames, support a superposed series of

shallow trays, 6, the bottoms of which are of corrugated sheet-metal. Within these trays rest the cathode boxes, 22, for receiving the peat or other material from which the moisture is to be expelled, the bottoms of these boxes being permeable, and illustrated as formed of copper or iron wire-net, 23, supported by heavier net, 24. As shown, two of these cathode boxes are supported side by side in each tray and connected electrically in parallel through the corrugated bottom of the tray. Above each cathode box an anode plate, 20, 21, of iron is suspended by chains, 19, from transverse beams, 17, 18. These beams are supported upon short cross bars, 15, 16, secured to vertical side bars, 7, 8, which in turn are hung by links, 9, from a cross-bar, 11, and are free to move vertically in upper and lower guides, 13, 14. By means of a lever, 10, the beams, 17, 18, together with the several anode plates, 20, 21, suspended therefrom, may be moved upward into the position shown in the figures to permit the cathode boxes to be moved into place. The anode plates are then lowered into operative position in contact with the material in the trays, the chains, 19, being slack in order that the plates may follow the decreasing bulk of the material as the moisture is expressed. The anodes in each horizontal series are connected electrically in parallel, whereas the several superposed cells are series connected. Handles, 25, are provided for convenience in moving the cathode boxes and troughs, 4, for carrying away the expressed moisture. It is stated that the fall of potential through each cell is about 15 volts, and that about three hours are required for the removal of 40 to 50 per cent. of the moisture.—**Clinton P. Townsend,** *Elect. World and Eng., Vol. XLI., No. 9, Feb. 28, 1903,* p. 365.

MECHANICAL.

Grisson Gears.

THE author discusses the theoretical principles and constructive details of Grisson gears. There should be left enough material between the working curve and the rapid shaft to prevent the wheel being destroyed at this weakest point. Fractures of the tooth itself are entirely impossible, as the two cam-teeth, forming an angle of 180degs., possess a very high strength. The gears are made either of grey cast-iron or of steel, according to the use they are intended for, with ratios ranging between 1·5 and 1·50, those from 1·8 to 1·30 being most frequently used. Some gears show departures from the fundamental rule, according to which the ratio of two tooth-wheels should be equal to the ratio of their pitch-circles. Grisson gears are particularly advantageous on account of their low cost; they are, however, not suitable in any case where high ratios are necessary, as, for example, with fast motors. A special modification adapted for high speeds is described.— **Grisson,** *Zeitschrift des Vereins Deutscher Ingenieure, XXXXIII., No. 18,* p. 644, May 2, 1903.—*A. G.*

Pipe Fitting.

IT is laid down as a rule in some handbooks that the pipe should never be run through to the face of the flange. If the threads are good on both flange and pipe, and the tapers of both happen to agree throughout, this may give a tight joint at first, but it soon begins to leak when subjected to vibration under pressure. With careful erecting the following procedure will give joints that are permanently tight:—(1) The threading of the pipe end should be carried back slightly more than the threaded depth of the flange, care being taken to have the tapers of the two agree throughout; (2) the pipe should be run through the flange practically "to refusal;" (3) flange and pipe end should be faced off together. The gasket should be of such size as will cover the joint between the pipe end and the flange. The best form of flange for use with 140 lbs. pressure, or above, is the one with raised bearing face, as this form gives a certain amount of flexibility in approaching the faces, is easiest to adjust the gasket on, and makes possible a good distribution of the bolt tension. It also has the advantage over a plain flange face, that it is easier to give it a bevel, if necessary, to fit any special situation. Steel flanges are capable of giving better distribution of bolt-pressure than iron, as they are somewhat lighter and more flexible for the same pressures. In order to have a new piping job as free as possible from unnecessary stresses, it should be given every facility for adjusting its position when first put under pressure. The first tightening of bolts should not be carried any further than is possible with a short leverage on the wrench, the final tightening being done while piping is hot, though, preferably, not under full gate of steam. Each fitting and length of pipe should be washed out before erection. Every piece of pipe should be looked through for possible obstructions. Inspection of fittings should be made with the aid of a narrow cape chisel, a 2-lb. hammer, several files and some stiff wire, and anchors should be examined by filing off some of the boss and noting the character of the union between anchor and metal.—**W. H. Ripley,** *Street Rly. Jnl., May 2, 1903,* p. 667.

The Construction and Working of Machine Reamers and Reaming Heads.

A HOLE bored with a single tool is not to be compared with a similar hole finished with a reamer. This is especially the case if the hole is a bush or bearing of any description. One great feature to watch in a shop equipping itself with reamers is to supply standard sizes only; thus the number of reamers can ke kept down to a minimum. Reamers are either solid or adjustable, and the latter are sub-divided into solid-stalk reamers, shell reamers, and reaming heads. Various forms of the solid reamer are illustrated, but this type is now discarded for repetition work, owing to short life and want of adjustment. Adjustable reamers are next illustrated and described in considerable variety. Above 4 in. the shell reamer evolves into the reaming head, in the construction of which one great point to avoid is an excessive number of cutters. Reamers for cylinder work, especially when used in the vertical boring mill, need have no more than four or six cutters; in fact, excellent results have been obtained with heads 16 ins. in diameter having but four cutters working. To reap the full benefit of having a full set of reamers in any shop, constant use must be made of them in the lathe, boring and turning mill, and drilling machines. The practice of constraining a reamer is entirely opposed to its successful working, and the "floating" arrangement, which gives all the features of a flexible head, may often be used with advantage. Among the advantages of the extensive use of reamers the following may be mentioned:—(1) Absolute interchangeability easily obtained, (2) greatly reduced cost of machining holes requiring accuracy, (3) low cost of boring holes having a length several times their diameter, (4) lathes worn to such an extent as to be unfit for boring can be used for reaming by the use of reamers with "floating" attachment, (5) perfect finish in all holes used for bearings.—**E. Bruce Ball**, *Engineering, May 8 and 22, 1903*, pp. 608–610 and 677–680.

WORKS MANAGEMENT.

Foundry Shop Orders.

IT is important to have a system of keeping accurate costs of all articles made for use in the plant, and the purpose of this article is to outline the methods used by the author. No work is done without properly-written shop orders, and three forms given in the article are here reproduced. Form 1 is made out in five carbon copies, one each for the office, the foundry, the machine shop, the smith's shop, and the pattern shop. The factory clerk distributes the forms, and makes out a card, Form 2, on which the foreman notes the time spent by the workman on the job. The foundry order is made out when the patterns are ready, and the foreman turns in this order as soon as it is finished. Similar cards are made out for other shops, and on completion of the order all order copies and time cards are brought to the office by the factory clerk. To preserve a permanent record a

OFFICE COPY. Order No. A 7

KEYSTONE FOUNDRY COMPANY.

To

Please Prepare for Foundry

The Following. Turning in Order When Work is Completed.

Date March 1, 1903

Number	Article	Pattern Number	Weight	Machine Work
100	Hammers	257		
100	Butts	256		
100	Handles			
	Wooden pattern necessary for butts			
	we have pattern for reamer.			

Keystone Foundry Company

Per E. W. M.

Order No.			Price		
Acct.		Class	Cost		

4-03

FOUNDRY SHOP ORDERS: FORM NO. 1.

card, as Form 3, is made out for the pattern and the articles, these cards providing space for all material and labour. The cards are entered up at the end of the month on the labour distribution sheet, which has double columns for each of the principal accounts, to which the different articles are charged, one column for supply and one for labour. With necessary modifications, this system could be used with advantage by a great many foundries who keep no account of matters of this nature.—**R. W. McDowell,** *The Foundry, May, 1903, Vol. XXII., No. 129,* pp. 95-98.

Storing Patterns.

SOMETIMES patterns that should all be kept in one room are scattered around in three or four different rooms or buildings. Shelves or racks are put up without any regular order being observed. Shelves or sections in which patterns are stored are seldom marked clearly in large figures, as they should be. Still more seldom is a particular place marked for each pattern. Often the shelves are built too high, so that ladders are a constant necessity, and there will be more time wasted hunting and handling the ladders than it should take to handle the pattern, not to mention the occasional dropping and breaking of patterns. I recommend the arrangement of floors and shelves built in sections, with passageways about 4 ft. wide between sections. For patterns which are too large for these passageways and sections, one or more platforms 12 ins. high should be built near a large door. The sections and platforms should be numbered with large figures. The pattern numbers for the shelves are printed consecutively with the typewriter on sheets of paper with the rear side gummed, and are cut from the sheets as fast as patterns are located on the shelves, and stuck on the edge of the shelf as near as possible to the place where the pattern is to be kept. It is well to keep the larger patterns on the lower shelves and smaller ones on the middle and upper shelves, as far as possible. The shelf numbers may be printed on sheets of cardboard, or perhaps taken from calendars with large figures, and tacked on the uprights. It is best to number patterns consecutively in the drafting room, and fill up the pattern-house shelves as fast as the patterns are made, regardless of the order of their numbers, and index them as fast as they are placed on the shelves, so that it is always easy to find a pattern by the index.—**S. A. Worcester,** *Am. Machst., May 16, 1903,* pp. 615-616.

KEYSTONE FOUNDRY COMPANY—DAY WORK TIME CARD.

No. 86 Dept. Pattern Shop Order No. 97

Nature of Work Running 100 Pannier handles

Date 3/1/03 Signed Halloran

Began 3/1/03 Finished 3/4/03

Overtime Began. Finished

TO FOREMAN:—Return this card to office with order immediately after completion of order, giving name of men engaged on order, and your count of his time.

KEYSTONE FOUNDRY CO.
C. W. HOWELL, Manager.

MORNING.								AFTERNOON.								The Space for Office Use
BEGAN.				FINISHED.				BEGAN.				FINISHED.				
7	15	30	45	7	15	30	45	1	15	30	45	1	15	30	45	TIME 3 da 2 hrs
8	15	30	45	8	15	30	45	2	15	30	45	2	15	30	45	RATE 3 50
9	15	30	45	9	15	30	45	3	15	30	45	3	15	30	45	VALUE
X	15	30	45	10	15	30	45	4	15	30	45	4	15	30	45	12.95
11	15	30	45	11	15	30	45	5	15	30	45	5	15	X	45	CHARGE
12	15	30	45	12	15	30	45	6	15	30	45	6	15	30	45	

NAME PATTERNS & FLASK ORDER NO. 97

ARTICLE 1 Pannier butt pattern No. 498

DATE BEGUN 3/1/03 DATE FINISHED 3/1/03

MATERIAL | WEIGHT | RATE | COST

4902

FOUNDRY SHOP ORDERS: FORMS 2 AND 3.

WATERWORKS AND SEWERAGE.

Biological and Chemical Laboratories of New York Water Depa ment.

MT. PROSPECT laboratory, Brooklyn, has been recently enlarged, and its scope of operations greatly increased. The work conducted may be sub-divided thus :— 1. Supervision of present water supplies of New York City. 2. Tests and analyses of supplies, such as cement, coal and oil. 3. Sanitary investigations for the Commission on additional water supply. 4. Experiments on soil physics for the Commission on additional water supply. The problems involved in the storage of the Croton water are largely biological, and the Katonah laboratory, in its scope and equipment, resembles the old Chestnut Hill laboratory of the Boston water works. In addition to the work of water analysis carried on at Mt. Prospect laboratory, much work is continually being done in testing the supplies purchased. This work consists chiefly of the determination of the heating power of coals, tests of lubricating oils, etc. Boiler scales are also examined and much experimental work done in connection with problems of engineering chemistry. The laboratory is also well equipped for physical and chemical tests of cement. The selection of an additional water supply for the city of New York has involved an extensive sanitary investigation of all the possible sources which are available for this purpose, and when it is considered that the territory involved covers an area of about 15,000 square miles, the magnitude of the problem may be appreciated. The headquarters of this field work is at Poughkeepsie, where a laboratory has been established. There are three rooms completely equipped for physical and biological examinations of water and for experimental work. No chemical work is done there, but samples that need to be analysed chemically are sent by express to Mt. Prospect laboratory. One of the most interesting and important studies is that of the saltness of the water in the lower Hudson, and it is hoped that these studies may be carried to such completeness that it will be possible to predict to what extent salt water will be found in the river in the vicinity of Poughkeepsie at times of greatest drought. In connection with the investigation of the ground water of Long Island, studies are being made of the sand of Long Island with reference to its physical qualities, such as its effective size, uniformity coefficient and porosity. Experiments are being made also upon capillarity, percolation. etc., using carefully selected materials covering a wide range from clay to coarse sand. **George C. Whipple,** *Eng. Rec.*, *May 9, 1903, Vol. XLVII., No 19,* pp. 487–488.

Recording Pressure Gauges in Waterworks Management.

MANY water-works systems are now equipped with recording gauges, and even small plants find it to their advantage to have at least one gauge connected with the main pipe system. By the use of these instruments, the manager or superintendent of a water-works system is kept informed of what is going on, the height of water in tanks or reservoirs or the pressure of steam on the pumping station boilers. When a large fire causes great destruction of property, with, perhaps, loss of life as well, the fire department is often severely criticised, and sometimes the firemen attempt to put the blame on the water department, saying that the pressure was too low or main gates were shut that should have been open. In such cases the recording gauge charts will show the real condition of affairs. Much damage to water mains is caused by shocks or water ram and the origin of the trouble is sometimes hard to locate. In cases of this kind the recording gauge is of great service, as it fixes the exact time that the shock occurs, and this will often furnish the needed clue to the mystery. If several gauges are distributed about the system the location of the disturb ance is often indicated by the records. the one nearest the source of trouble will show the most marked variation in pressure. When installing a recording gauge it is best to connect it with the water main by means of an independent service pipe wherever possible, and avoid putting it on the piping system of a building, where the gauge will be subjected to sharp shocks whenever the fixtures are used. These variations in pressure will confuse the record and the vibrations have a tendency to injure the spring of the instrument. In selecting a gauge, care should be taken to get one which will register a maximum pressure at least 40 lbs. higher than the normal pressure at the point where it is to placed. This avoids unduly straining the spring, causing a permanent set in the metal, and also allows shocks and maximum pressures to be recorded.—**A. O. Doane,** *Eng. Rec., May 9, 1903, Vol. XLVII., No. 19,* p. 486.

The Septic Tank at La Grange, Ill.

TO avoid passing all the storm water from the drainage system through the septic tank, and to intercept the sewage and the first flood wave of storm water, a weir was built at a high point in the main and a 12-in. sewer-pipe laid from the

weir to the septic tank. That portion of the sewage below the top of the weir passes into settling chambers, where any sand or mud washed from the streets is prevented from entering the tanks. The chambers are built in duplicate, each being 12 ft. by 14 ft. by 6 ft. deep, and each chamber has an inlet and outlet valve, as well as a valve through which the contents may be drained into the main sewer. The septic tank consists of three separate compartments side by side, each 100 ft. long, 10 ft. wide, and 10 ft. deep, covered with a concrete roof 6 ins. thick. The depth of the sewage in each tank is 7 ft. Sewage is stored from twelve to eighteen hours, and flows from the tanks over three weirs in thin transparent sheets, dropping 18 ins. into a shallow basin, from which it discharges back into the main sewer. Each compartment is provided with a regulating valve at the inlet, and a separate weir, over which the effluent passes. Baffle boards are fitted near the outlet, to prevent gas from escaping or scum to pass out over the weirs. The plant was designed by the writer, and has been in continuous operation since November 1901. Its object was to remove the cause of offensive odours produced by decomposing sewage, and this has been successfully accomplished. The design provided for filtration of the effluent if necessary, but at the present time there has been no occasion for such treatment. The beneficial effect of mechanical action on the sewage in assisting the action of the tank is apparent in the La Grange plant. At the end of continuous operation for one year a compartment was drawn off. Its sides were slimy, and on the bottom there remained a thick slime about 1 in. deep, which, on removal of its water, left a dry scum less than ⅛ in. thick.—**W. B. Ewing,** *Eng. Record, Vol. XLVII., No. 8, Feb. 21, 1903,* p. 200.

Experiments on the Efficiency of Centrifugal Pumps.

AFTER referring to previous experimental work, the author says it will be seen that the questions which require further study are: (1) The relative efficiency of curved vanes and radial vanes at high speeds; (2) The efficiency of the vortex chamber; (3) The efficiency of guide passages; (4) The possibility of high lifts by centrifugal pumps with a single wheel. The experiments here described were carried out in the Hydraulic Laboratory of University College, Bristol, in August and September, 1901, and the general conclusions to be drawn from the results of the investigations may be thus summarised:—(1) In high-speed wheels the effect of moderately recurving the vanes at the outlet is beneficial, especially when the water is discharged into a free vortex, the curvature being such that the velocity of flow of water through the wheel is uniform. (2) Wheels which discharge the water into guide passages give a higher efficiency than those which discharge the water into a free vortex, this advantage being more marked in the case of wheels with radial vanes than in the other type. (3) The number of guide passages should be not less than four, and the areas at inlet should be such that the velocity of flow into the passages should be equal to the velocity of discharge from the wheel, to avoid losses from sudden changes of velocity. The author suggests that increased efficiency and considerable economy in material and space occupied would result from the adoption of a high-speed direct motor-driven pump, designed on the principles laid down above, although he admits that for dealing with very large quantities of water at a low lift, the present slow-speed pump driven direct from a steam engine has great advantages. The paper includes tables and diagrams embodying results of the trials.—**T. E. Stanton,** *Proc. I. Mech. E., Feb. 20, 1903.*

Hydraulic Experiments on a Plunger Pump.

AFTER describing and illustrating the pump and auxiliary apparatus employed, the author states that the object of his experiments was to obtain further information on the following points:—(1) How the "slip" or the "discharge co-efficient" of a pump, not fitted with a vacuum vessel, also the "water ram" pressure in the suction pipe are affected by—(*a*) a change of outlet or delivery pressure when the speed remains constant; (*b*) a change of speed when the delivery pressure remains constant; (*c*) a change in the length of the suction pipe with the other conditions remaining unchanged; (*d*) running the pump without a suction valve. (2) The exact behaviour as regards the opening and closing of the suction and delivery valves under various conditions of running. (3) The speed at which the plunger separates from the water during the early part of the stroke and catches it up later on, thereby producing a violent bang in the suction pipe. (4) The loss of pressure due to the friction of the water passing through the valves and passages of the pump. (5) The mechanical efficiency of the pump under various working pressures. (6) The effect of fitting a vacuum or air vessel to the suction pipe. The results of the tests are discussed by the author in some forty pages of his paper, and they are elucidated by thirty-eight figures, containing

a much greater number of diagrams. Briefly stated, the following are the most important deductions from the experiments upon this particular form of pump:—(1) That, without a vacuum vessel on the suction pipe, the quantity of water delivered depends on the speed of the pump, and on a "co-efficient of discharge," which varies with the conditions of working. The quantity pumped may vary between 94 and 150 per cent. of the plunger displacement. (2) That water-ram pressures in the suction pipes of pumps, without air or vacuum vessels, are much greater than shown by the usual theory. (3) That the serious banging often heard in suction pipes is due to separation of the plunger and the water, and to their subsequent concussion. Discontinuity between the plunger and the water may be avoided (*a*) by the use of a vacuum vessel; (*b*) by increasing the diameter of the suction-pipe; (*c*) by shortening the suction-pipe; (*d*) by reducing the pump speed. (4) That uncontrolled pump valves do not act in the simple manner supposed, except when the pump is running at low speed, and when delivering against a low head. The author is aware that the results obtained on this small pump may not occur in so marked a manner in larger pumps, but he trusts that the results may be of sufficient interest to lead other engineers to carry on similar experiments on a larger scale.—**Prof. Goodman,** *Proc. I. Mech. E., Feb. 20, 1903.*

MISCELLANEOUS.

The Contributions of H. F. E. Lenz to the Science of Electromagnetism.

HEINRICH FRIEDRICH EMIL LENZ was a voluminous writer as well as an indefatigable investigator, and the catalogue of the Royal Society contains a list of some fifty of his contributions. In this article the writer refers in detail to the part taken by Lenz in the establishment of the science governing the phenomena of magnetically induced currents, and points out the relation which his work bears to that of Faraday, Henry, and others. As an investigator Lenz is no doubt entitled to the honour of being one of the foremost scientists who established the principles of electromagnetism. — **Dr. Stone,** *Jnl. Franklin Inst., May, 1903, Vol. CLV., No. 5,* pp. 363-384.

IMPORTANT

Arrangements have been concluded with Mr. Chas. S. Lake, an engineer well known in railway circles, to contribute month by month a series of Notes on Locomotive Engineering, commencing with the August issue.

These Notes, which will form a permanent characteristic of the magazine in future, will be of considerable value to all those who are interested in this special branch of engineering, alike from the standpoints of manufacturers, purchasers, and independent onlookers who may desire to have at hand a summary of information upon this subject.

NEW BOOKS.

Power Gas.

THE first installation of plant designed by Dr. Ludwig Mond, F.R.S., for the production of combustible gas from small coal, and the subsequent recovery of sulphate of ammonia as a by-product, was made at the works of Messrs. Brunner, Mond & Co., Northwich. This apparatus was merely intended to gasify a few hundredweights of slack per hour, but the plant was enlarged from time to time in order to meet increasing demands, as its advantages became more fully recognised. At the present time, the plant is of such size that some 250 tons of slack are daily gasified, the output of gas being about 37,000,000 cubic ft. per day, while sulphate of ammonia obtained therefrom as a by-product, amounts to more than 10 tons. The large volume of gas thus generated day by day provides fuel for heating and evaporation, and is used in various chemical processes carried on at the works; it serves to warm the offices, to cook the workmen's dinners, and to provide fuel for the large gas-engines that are used in the generation of electricity for the works, and for lighting the township of Northwich. The experience gained in the operation of this installation has resulted in the improvement of the plant and apparatus employed in connection with the patents, and the Power-Gas Corporation, Ltd., of London and Stockton-on-Tees, has now been formed for the purpose of developing, not only the Mond patents, but also the Duff and the Talbot patents for gas production. A considerable amount of useful information upon the manufacture and various applications of producer-gas is contained in a volume recently published by the Power-Gas Corporation.* Standard sizes of gas plant are manufactured at the Stockton works of the company, the capacities varying from 2½ tons to 100 tons of fuel daily, representing equivalent values ranging from 250 h.p. to 10,000 h.p. One installation of 25,000 h.p., and others varying from 250 h.p. to 20,000 h.p., are already in operation; and some idea of the important nature of the industry may be formed from the statement that thirty of the plants in question are now developing an equivalent of nearly 200,000 h.p., while the total capacity of existing installations is 270,000,000 cub. ft. daily. The advantages of using power-gas are very clearly set forth in one section of the handbook, and some of these are particularly striking. The gas is produced from the cheapest quality of coal, at a cost of the gas of less than one-halfpenny per 1,000 cub. ft. When used in large gas engines the product of 1 ton of slack will give 2,500 h.p. for an hour, and a given quantity of fuel will produce four times the power obtainable from it with a steam engine. The fuel-cost per indicated horse power is stated at one fortieth of a penny, and the waste with intermittent loads is reduced to a minimum. The use of fuel-gas abolishes the smoke nuisance; its cleanliness and regular composition render it invaluable in all heating operations where the flame comes into direct contact with the material to be heated. It is an ideal gas for metallurgical purposes, and for obtaining high temperatures generally.

Fig. 1 is a diagram of the Mond Gas plant, and the method of production and the recovery of by-products may be thus briefly outlined:—Slack is mechanically conveyed to the storage hoppers, whence it is fed into the producers, in which combustion takes place at a comparatively low temperature, to prevent the formation of clinker and the destruction of ammonia. This is accomplished by a blast of hot air and steam. The producers are shown at

* To be obtained of the Company, on application, 39, Victoria Street, London, S.W.

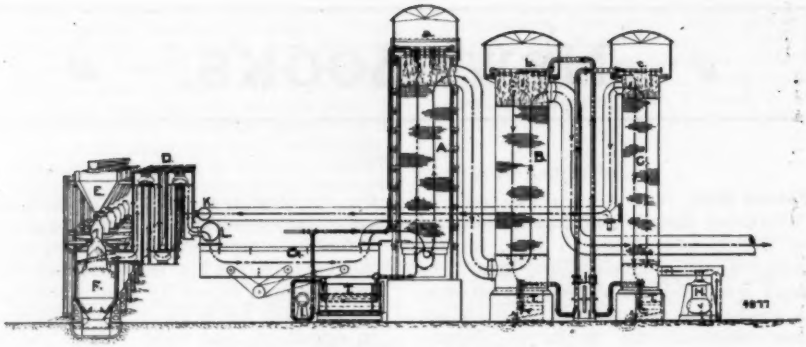


FIG. 1.—DIAGRAM OF MOND GAS PLANT.

A. Ammonia Recovery Tower.
B. Gas Cooling Tower.
C. Air Heating Tower
D. Tubular Regenerator.
E. Hopper.
F. Producer.
G Mechanical Washer.
H Roots Blower.
J. Tanks.
a. Acid Distribution.
b. Cold Water Distribution.
c. Hot Water Distribution.

the left-hand side of the diagram, and the blast proceeds from the last tower on the right-hand side. After leaving the producer the gas passes through a regenerator, where part of the heat of the gas and steam is transferred to the blast on its way from the air-heating tower. The gas then passes to a mechanical washer, where it is purified by water thrown up into fine spray by a system of revolving dashers. The acid tower, the first of the series shown in the diagram, is next entered where ammonia is washed out from the gas by a weak solution of sulphuric acid; then the gas passes on to the second tower, in which it is cooled and further cleansed by a downward flow of water; and from this tower the gas passes to the supply mains. The last tower shown in the diagram is for heating the blast supplied to the producer.

The next section of the volume before us deals with typical figures obtained from the working of plants of 20,000 h.p. and 1,000 h.p., and we then come to some particulars as to the operation of large gas-engines with Mond Gas. A 550-h.p. producer-gas engine, built by the Premier Gas Engine Co., of Nottingham, is given as an example, although there are, of course, many other firms making a speciality of such engines, and it is worthy of mention that, even in cases of intermittent working, and after providing for stand-by losses and steam raising, a perfectly safe basis for the calculation of fuel consumption is 1 lb. per i.h.p. Steam required for the gas-making process can be raised by utilisation of heat contained in the exhaust from the gas engines, thus increasing the fuel economy of the system by about 20 per cent. This method of utilising the exhaust from internal-combustion engines is one that ought to be considered by users of all such motors, whether fired by gas or any other form of fuel. A most important development of the power-gas system is to be found in the distribution of gas over large areas from central stations. In the handbook before us we find some interesting particulars relative to the South Staffordshire Mond Gas Company, a corporation formed for the purpose of making and distributing gas to manufacturers and others throughout the district covering an area of 123 sq. mls., and including some 25 towns and townships with an aggregate population of 640,000 inhabitants. In dealing with central stations, the Company point out the economy of gas engines for driving dynamos, and the suitability of modern gas engines for running alternators in parallel. Among various other directions in which power-gas can be applied, the following may be noted:—Boiler-firing, glass manufacture, iron and steel making, foundry work, general metal-work, and in

fact all industries where furnaces, kilns, ovens, evaporating vessels, and similar appliances are employed. The book concludes with some notes upon the value of sulphate of ammonia in agriculture, and some views showing on one hand the cumbersome and smoky forms of steam plant sometimes employed, and on the other, the compact and smokeless nature of plant in which power-gas is utilised. The industry to which we have briefly referred is of the utmost importance. Its development will materially reduce the alarming waste of coal that now takes place, and its universal application in large towns would effectually cure the smoke nuisance. Those who are interested in the subject will find much useful information in the volume to which reference has been made.

Modern Electric Railway Motors.—By G. T. Hanchett. (New York: Street Railway Publishing Company.)

This work is primarily intended to meet the requirements of men who are employed in handling or repairing electric railway motors, and whose knowledge of electrical matters is only of a quite elementary character. The more serious student will find, together with much that will be superfluous to him, a useful exposition of present American practice in the construction, management, and repairs of these motors. The author opens with a discussion of some of the various forms of field magnets which have been employed in railway motor work, differentiating between those which are obsolete and those which are in present use. His second chapter is devoted to the consideration of the principles of armature winding. It appears to us too brief to be of much value to the readers to which the work is primarily addressed, but the engineering student will find in it the reasons for the displacement of ring windings by drum windings for railway motors. The next three chapters are occupied with details of construction and arrangement of the field coils, armatures, commutators and brush holders. These chapters, especially the last one, deal with various details of practical importance. Then follows a long chapter on motor casings, in which most of the forms which have been and are now employed in American practice are described and illustrated. A short chapter on motor suspensions contains a very clear explanation of the conditions to be fulfilled, and of the various methods which have been adopted in order to satisfy them, as far as single reduction motors are concerned. Gearless motors are merely referred to as being "largely a future development commercially;" and the author does not seem to be aware that, as far back as 1890, they were introduced on the City and South London Railway, where they have been, since then, in continuous use. The chapter on bearings and gears contains some valuable warnings, which readers may be counselled to lay to heart, regarding the evils attendant on the use of much of the cheap babbiting material sold under the name of antifriction metal. The treatment of gears is extremely brief, and might be considerably extended with advantage. This chapter is followed by a few short notes on lubrication and some general remarks on various points of present railway motor practice, and a useful and practical chapter on management and repairs. The work concludes with a worked-out example of the design of a railway motor. This matter is not, however, treated with sufficient fulness to be of much value, a fact of which the author is evidently aware, as he cautions his readers that he does not pretend to do more than give an idea as to how the problem is to be attacked, and to indicate the class of information which the would-be designer must acquire. It appears to us that the author would be well advised in future editions either to treat the subject of designing railway motors in an adequate manner or else to omit the chapter entirely. G. W. de T.

Briquettes and Patent Fuel.—By Philip R. Björling. (London: Rebman, Ld., 1903.) Price 15*s.* net.

In the work now before us the author has combined the subject-matter of some articles written by him in the *Colliery Guardian*, and in the American annual, *The Mineral Industry*, and he has added, for the guidance of future inventors, a chapter on all the different classes of binding material for the manufacture of fuel briquettes. After a brief historical sketch, in which it is made clear that the briquetting of small coal is by no means a modern invention, the author describes the processes followed in the making of briquettes, and discusses at length the many types of machinery and apparatus employed in this industry. The chapter devoted to "Bonds" is particularly comprehensive, and the volume concludes with various tables giving calorific values, and other information relative to patent and natural fuels. As showing the extent of the briquetting industry, it may be mentioned that in the year 1901, more than 1,000,000 tons of briquettes

were exported from Great Britain, while in 1897, 6,233,499 tons were exported from Belgium. Those who are interested in the manufacture of patent fuel, either from a mineralogical or a mechanical point of view, will find adequate information in Mr. Björling's work, which, we may add, is excellently printed and profusely illustrated with diagrams of the machinery and plant employed.

The Australian Handbook: 34th Year.—(Gordon & Gotch, London, 1903.) 10*s.* 6*d.* net.

In the present edition of this compendious volume, various alterations have been made with the object of facilitating reference. A Commonwealth Section is now formed, including statistics and information relative to revenues, railroads, the postal service, and the federal tariff at present in force. A useful feature is the article upon the patent and copyright laws of the Commonwealth States and New Zealand. This article and the very complete list of importers should prove to be of considerable service to enterprising manufacturers and patentees. Among other matters of general interest contained in the handbook, are details concerning electric telegraphs, telephones, geological formation, land and mining regulations, sewage and irrigation works and technical schools. The volume contains the fullest possible information as to all the chief cities, towns, and villages in Australia and New Zealand, together with numerous maps of states, cities, and railway systems. To all who are interested in the export of machinery and other engineering productions to the Australian Colonies, this Handbook is an almost indispensable guide.

Valves and Valve-Gearing. A Practical Text-Book for the use of Engineers, Draughtsmen, and Students. — By Charles Hurst. Third Edition, revised and enlarged. (London: Charles Griffin & Co., 1902.) Price 8*s.* 6*d.*

As this work has already been before the public for some years, and has shown its practical value by the demand for a second and a third edition, it is unnecessary that we should present to our readers an extended review upon the present issue. As before, Part I. treats of the ordinary slide valve and modifications thereof, and Part II. is devoted to Corliss valves; but the whole of the matter has been carefully revised, and a third part has been added, on double-beat valves and miscellaneous gear. This is a most useful addition in view of the fact that steam-engine design of the future will involve an extended use of the double-beat valve, which is specially suitable for superheated steam, owing to the absence of rubbing action between the valve and its seat. In Part III., Mr. Hurst discusses the essential features of the double-beat valve, and the type of valve motion generally employed therewith, and then describes and illustrates a tripping arrangement which is useful for large winding engines. For non-reversing engines a different form of gear is more convenient, and that made by Messrs. Robey & Co. is mentioned as being the best-known English example of the type. In this, the method of governing and tripping is similar to that of an ordinary Corliss gear, and the range of tripping depends upon the clearance of the catches and the lap, just as in the Corliss gear the range depends on the ratio of the lap of the valve to its travel. Another very interesting form of gear described is the well-known Sulzer gear. The new chapter notices Beadle's rotary valve gear, a compact arrangement, realising to a very considerable extent the essential requirements of perfect equilibrium, unlimited speed, and small clearances. As a simple and yet thoroughly practical exposition of the whole subject, this handbook possesses a distinctive value to practical men.

Light Railway Construction.—By Richard Marion Parkinson, Assoc. M. Inst. C E. (London: Longman, Green & Co., 1902) 10*s.* 6*d.* net.

Under this title the author has written a very complete guide to the preparation and realisation of light railway schemes. He describes some of the legal and official technicalities which must be complied with before a light railway order can be obtained, and then passes on to consider various engineering details, such as gauges, curves and gradients, plans and sections, fencing, earthworks, bridges, tunnels, stations, and other works connected with the permanent way. A chapter following on "Steep Inclines" contains notes on cable traction, the toothed centre-rail and centre-grip rail system, and electric traction, which we are glad to observe is strongly advocated by the author for passenger services. The remaining chapters of the book are devoted to contracts, specifications, quantities and estimates, and there is a series of twenty appendices which embody much serviceable information. Although so extensive a subject cannot be treated exhaustively in a volume of some 240 pages, it must be admitted that the author has omitted very few, if any, essential points, and his work will be found a most helpful text-book both

to engineers engaged in light railway construction and to others who may be concerned with undertakings of this nature.

Gas, Gasoline, and Oil Engines.—By Gardner D. Hiscox, M.E. With 312 illustrations. (London: Sampson Low, Marston & Co., 1902.) 14*s.* net.

This is the tenth edition of a work devoted to the principles and practice of "explosive motors" as manufactured in the United States. The author has wisely cut down the length of the historical introduction which seems to be an inevitable feature in every work of this nature, and has made a successful endeavour to furnish details of working parts and to show the progress that has been made in motor design during recent years, especially in the atomisation and vaporisation of fuel. He has also paid considerable attention to questions such as the management and care of internal combustion engines, the descriptions and illustrations of electric igniters and exploders being particularly noteworthy. In what may be regarded as the second part, Mr. Hiscox gives descriptions of gas, gasoline, and oil engines made in America, though not necessarily of American origin. Unfortunately many of the illustrations are merely reproductions of perspective views, which do not afford much guidance to the designer, although they are interesting. Nevertheless a good many sectional drawings are given of newly introduced details, and in some cases of entire engines. The treatise is written in clear style, and forms a most useful companion volume to works on the same subject published in this country.

Brassfounders' Alloys.—By John F. Buchanan. (London: E. & F. N. Spon, Ltd., 1902.) 4*s.* 6*d.* net.

In this handy little work, the author has presented a very useful series of tables for the guidance of manufacturers and brassfounders. We are glad to observe that he protests against the common abuse of the term "bronze" by makers of special alloys that ought properly to be called "brass." When the time comes for a second edition of this handbook, we trust the author will avail himself of the opportunity to excise sundry American slang phrases, and to omit several pages ostensibly relating to bellfounders' alloys, but really containing some inconsequent remarks that are perhaps meant to be funny, and a lengthy extract from Schiller's "Song of the Bell." Such matter is utterly out of place, and goes far to spoil the excellent character of the work as a whole. W. H. W.

Calculations in Hydraulic Engineering.—Part II. By T. Claxton Fidler, M.Inst.C.E. (London: Longmans, Green & Co., 1902.) 7*s.* 6*d.* net.

Innumerable rules have been evolved for ascertaining, or, as it would probably be more correct to say, for predicting the flow of water in pipes and channels. Books have been written to expound some of these rules, and other books again to help the ordinary person to apply them. In his new book, Professor Fidler admits that mathematical accuracy is not attainable in computations of the kind, although a fairly reliable approximation is always possible. It seems to be unavoidable that calculations in hydro-kinetics should be conducted by the aid of empirical rules and co-efficients suggested by experimental evidence, and the object of the author has been to describe methods which, while not possessing all the simplicity of the most commonly used formula, certainly have the merit of avoiding its most serious errors, and can be applied with facility to the questions arising in practice. Tables of discharge are also given to reduce the amount of labour involved in such computations. Another useful feature of the work is that experimental results have been analysed with the view of affording reliable values of the co-efficient in the old formula, so that calculations can be worked out thereby with a fair amount of accuracy.

Lead and its Compounds. By Thomas Lambert. (London: Scott, Greenwood & Co.) 7*s.* 6*d.*

Only about one-half of this book is devoted to the matter suggested by the title, the remaining chapters relating to zinc, pumice-stone, oils, and pigments. There is a good deal of interesting information in the work, but we doubt if it will satisfy the metallurgist on the one hand, or the painter on the other.

Notes on Thermodynamics. By Prof. H. W. Spangler. Part I., Second Edition. (New York: John Wiley & Sons.) $1.00.

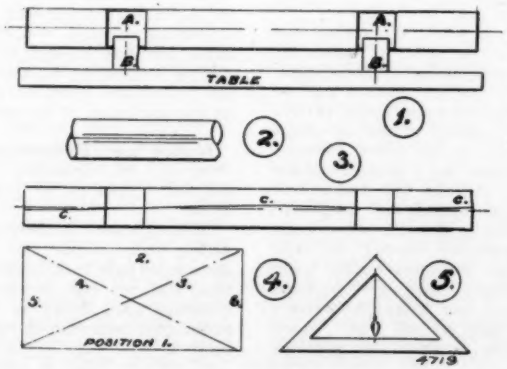
Although there is little that is new in this useful little treatise, all the most modern authorities have been consulted in its preparation, and we can commend the book to students who desire to make themselves acquainted with the theoretical side of the subject.

WORKSHOP PRACTICE.

This supplement is set apart for the discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited. In addition an award of One Guinea is made for what, in the opinion of the Editor, is the best contribution of the month.

Levelling and Testing a Surface Table.

After trying several methods, I have found the following a very accurate one for testing the truth of surface tables of large size, that is, over 12 ft. The common method pursued is with level and straight-edge, but the latter is scarcely ever to be relied on, for if accurate on its edge when lying on its side, its own weight will often cause it to "sag" when placed edge up. Most makers of straight-edges seem to think that, so long as you have a piece of parallel steel, it is good enough; they never think of proportioning it to its length—the same bar will be used for a 4 ft. 6 in. or 12 ft. First level the slab with a spirit-level, adjusting it by the screws or whatever means are provided for the purpose. Then, if possible, get a hollow cast-iron column somewhere near the length of the table: if turned parallel its whole length so much the better; if not, turn two bearings *AA*, Fig. 1, exactly the same diameter to drop into *V* blocks *BB*. I prefer the hollow cast-iron column because it is light and stiff. If the column is not handy, then a large diameter shaft will do instead. Now get the exact centre of the shaft at *AA*. Take a scribing block, the point of the scriber of which is ground flat spear-shaped, not cylindrical, a point so formed lasting much longer and giving a finer line. Set the point



LEVELLING AND TESTING A SURFACE TABLE.

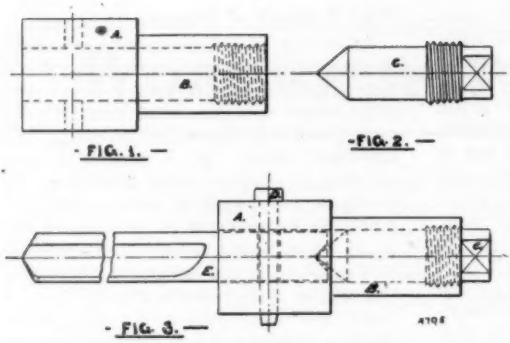
approximately at the centre, scratch a line on both bearings *AA*, and at *both* sides of the shaft, then revolve the shaft exactly half a turn (this is easily tested by trying the scribing point to the first lines); if the point is exactly central it will coincide with the lines at both sides, but if not it will be equally above or below as the case may be (Fig. 2). If not central, set it until it is, making a fresh mark each time, at a different place on the bearing. If the column is rough, whiten it all over except the bearings. Now, having got the exact centre, draw a line the whole length and at both sides; revolve the shaft half a turn, making the lines coincide at the bearings. Again draw a line the whole length and at both sides; you will then see at a glance whether the table is true in its whole length or not. If true, there will be a single line throughout on both sides: if not, the lines will show as in Fig. 3. The reason for taking the centre of the shaft at *AA* in the first place instead of at the ends will now be apparent. The bearings resting in the *V* blocks are fixed points or pivots. The table can be lifted or lowered at any point without affecting them. After the first lines are on the shaft, no more are necessary, whether these be true or not. Looking at the lines on Fig. 3, we will suppose *C* to be one and the same; this shows the table to be low on the left, high at the centre, and high on the right, by half the amount between the two lines. Set the table until the scribing point is equally between all three, it will then be true in that particular place. Now move the shaft to position 2, Fig. 4, try it in the same manner and set; and so on for the 3rd, 4th, 5th and 6th positions, at the same time correcting it with the level as you go on. I prefer a large triangle and plumb-bob (Fig. 5) to a spirit-level for such a job, the accuracy of the former when properly made being far above the latter. When scribing a centre line on a long shaft, the above method should always be used to ensure perfect accuracy; for, no matter what the amount of "sag" in the middle or at both ends, if you have two lines showing, you get the exact centre by dotting between them. THAMIS.

The Transit of Steam.

As an item of interest to our mechanical readers, the following illustrates the circuit through which steam travels from the point where it is generated round to the same point after expending its energy in a first-class vessel. It is generated in a number of boilers, and connected by piping to main lead of steam; this lead gradually increases as it goes aft to the engine-room, owing to the number of lines joining it. On the bulkhead separating the engine and boiler-rooms there is a non-return valve; passing through this it enters a separator, where all water held in suspension is shaken out by means of numerous twists and dash-plates. Leaving this, it enters a throttle valve, which is used when the ship, becoming frisky, lifts her stern out of the water, causing the propeller to rotate in air, and also the engines to race. It then passes through a stop valve, which can be shut from deck as well as from the engine-room, thus giving the captain control over the engines. Next step comes the engine-regulating valve, which is connected direct to the engines. Passing through the engines, where its pressure is reduced to below atmosphere, it leaves the low-pressure cylinder and enters the condenser, and is condensed by the cooling surface produced by circulating water through a series of tubes. The air pump draws it from the condenser and pumps it into a hot-well tank, from which it is then pumped by a hot-well pump through a grease extractor (where all grease and foreign matter not held in solution is taken out) into a feed tank, from which feed pumps draw and pump it again into the boilers, again appearing as steam. C. A.

Drilling a Hole with a Turret Lathe.

Turret lathes are now to be found in almost all the engineers' shops in the country, and their usefulness for turning various articles is generally understood and appreciated. That they may be used for drilling long holes concentric with the axis of the article turned, and of a size accurately to gauge, may not be very

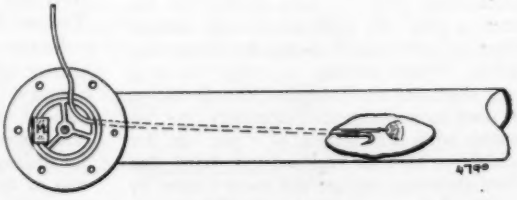


DRILLING A HOLE WITH TURRET LATHE.

widely known amongst the users of these lathes; and the following is a method by which this feat has been accomplished many times to the satisfaction of all concerned. If an ordinary drill and drill socket are inserted into the turret head it is usually found that, owing to the slight inaccuracies in the apparatus, due to wear and tear, the hole produced is not the exact size of the drill. For roughing drills this does not matter much, but where bits are used it is highly desirable that the holes should be the same size as the bit. In this case the drill socket *A* has a shank *B* which fits the hole in the turret, and the socket is bored right through with an axial hole $\frac{1}{64}$ in. or $\frac{3}{64}$ in. larger than the shank of the drill it is intended to hold. This hole is tapped for about $\frac{3}{4}$ in. in length at the end nearest the turret. *C* is a pointed centre, provided with a screw thread and a projection with two flats, by which it can be screwed into the drill socket *A*, as shown in Fig. 3. A hole is drilled through the head of the socket, perpendicular to its axis, and arranged to coincide with a slightly larger hole in the shank of the drill *E*, and the pin *D* is inserted to hold the drill and socket together. This pin is quite loose, and can be put in and taken out with the fingers. The shank end of the drill rests on the pointed centre *C* with a reverse cone, the angle of which is slightly larger than that of the pointed centre. The adjustable centre *C* need not be altered if the drill shanks are placed in a jig so as to ensure that the holes are all drilled at the same distance from the centre hole which fits on *C*. This method of fixing a finishing drill or bit ensures the production of a hole of exactly the same size as the drill which produces it. It is used in drilling and bitting dies of all sizes in the hole, and also in the manufacture of fuses. T. B.

Seeing Round a Corner.

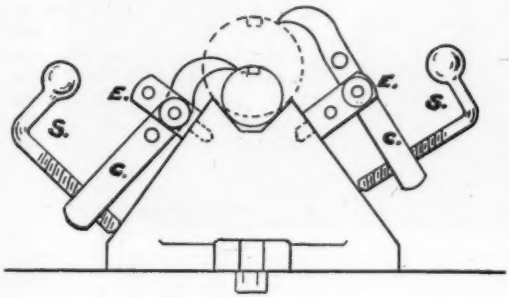
There are but few engineers who do not at times wish that their eyes were so made as to enable them to look round corners. To be able to examine the interior of some casting where the opening is too small to admit the head and where also an angle interposes would often be an advantage. The illustration shows a method, successfully employed, of fishing out the securing nut of the stop valve, which, with the constant chafing, had become detached and blown with the force of the steam along the horizontal length leading to the engine. A length of $\frac{1}{2}$-in. rubber pipe with a bit of $\frac{1}{4}$-in. gas pipe put in at the end to serve as a burner is attached to a gas bracket, and the other end pushed along the pipe to be examined. A small mirror is then placed upon the valve seat and tilted so as to show to the observer above the full interior of the horizontal length of pipe. The rubber pipe is then pushed along, to which is attached a hook with which to bring out the nut or any loose piece. H. B.

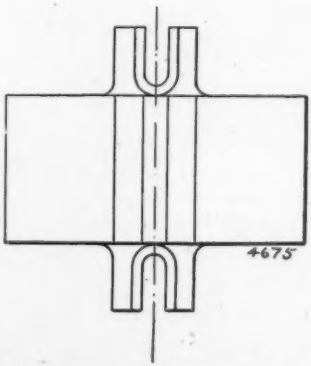


SEEING ROUND A CORNER.

Chuck for Keyway Milling.

The illustrations show plan and end elevation of chuck or V block for holding small shafts when milling keyways. The block is of cast iron, with tongue on underside, machined to fit slot in machine table. The cramps *C* have two or more holes which can be adapted to the different diameters of shafts. The binding screws *S* are first turned and chased, the handles are bent to right angles, which dispenses with the use of a key, and further affords a good leverage for tightening. S. F.

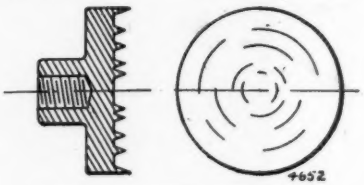




CHUCK FOR KEYWAY MILLING.

Chuck for Pattern-Maker's Lathe.

This chuck is cast in gun-metal and turned on the face, as shown in section; each ring is then cut away in parts as shown. The wood to turn is held up to the chuck, and a blow from the mallet does the rest. T. H. F.



CHUCK FOR PATTERN-MAKER'S LATHE.

Fixing Shafting.

The following method of fixing shafting to the underside of *H* steel beams is at once rigid, simple, and also speedy. To begin with, let us suppose that the beams are level both laterally and transversely, and also that the hangers are of the usual type with sole as shown at *A*, Fig. 1. The first thing is to get blocks cast from each hanger, corresponding to the dimensions of the sole of hanger as shown by *B*, with holes cored in them for the hanger bolts and also for the head of the bolts, so that the heads do not project above the flush. Next we require four *C I* clips at shown at *C* bolted to the blocks *B*, and gripping the lower flange of the beams. If these have been cast and prepared, then we can at once proceed to fasten them on to the beams. Previous to this, however, it is better to strike a line on the under side of the beams corresponding to the line of the front of the sole of the hangers—that is, at a distance *X*" from the centre line of the shaft. Having marked this line on each beam, we can secure our front blocks to the beams, bringing the front of each to coincide with our line. The back block may be left loose until we raise the hangers. After having fastened on all the blocks, we can proceed to lift up the hangers; and as these are

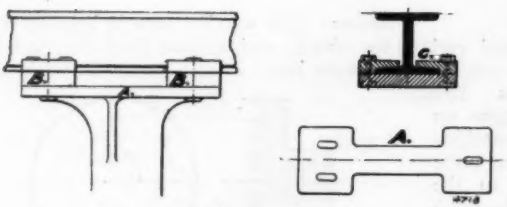


FIG 1.

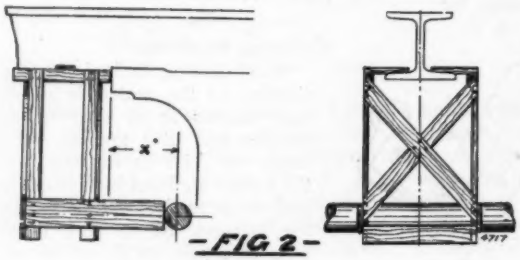


FIG 2.

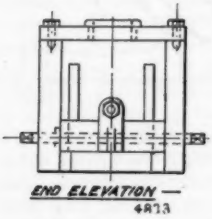
FIXING SHAFTING.

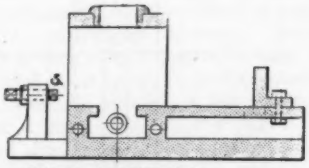
usually provided with slot holes for adjustment, we require some means of testing them to see that the centre of the shaft is parallel with our original line, and for this purpose I got a frame made to fasten to the beams with two arms projecting from it, one on each of the bushes, and also a small piece shaft to fit the bushes, and also project beyond 3″ or 4″. Fig. 2 shows the frame, also the way it was used to bring each of the hangers into line, by making the piece of shaft which projects through the bushes touch the ends of the arms on the frame. If everything has been done carefully, each hanger being tested and brought up to the ends of the arms of our frame, also noticing at the same time if the front blocks are exactly up to the line, then the shaft will be practically parallel with it, and all we require to do is to adjust the hangers for level. I adopted the above method some time ago, when putting up five lengths of 3″ shaft each 140′ 0″ long, and it worked first-rate and saved a good deal of time in erecting.

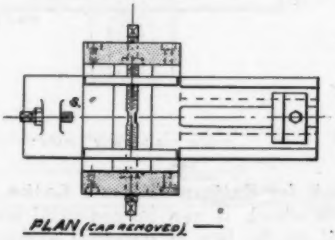
"MILLWRIGHT."

A Drilling Jig.

The illustrations below show a jig arranged for drilling the fork ends of connecting rods. It consists of a cast-iron fixing provided with T-headed slots at right angles, in one of which a differential screw is fixed for the purpose of expanding or contracting the side jaws which clip the forging. To the sides of the casting, vertical plates are fixed, which, in turn, support a cap provided with a hardened cast-steel bush as shown. A tail stop and setting-up screw determine the position endways, and allow for any slight adjustment which may be necessary. By placing the work in the jig







A DRILLING JIG.

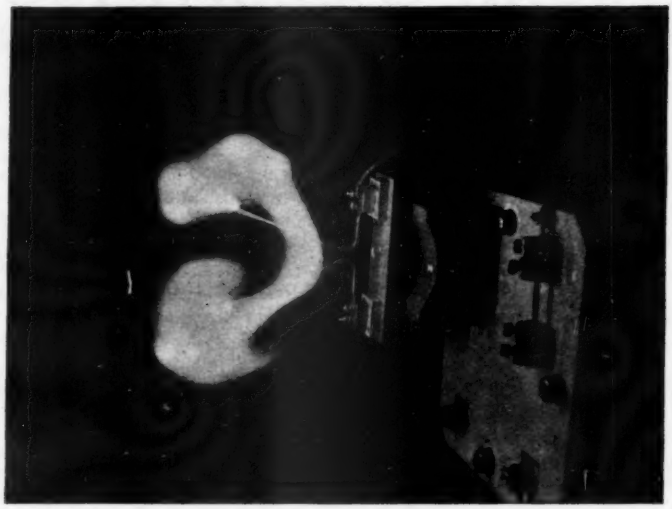
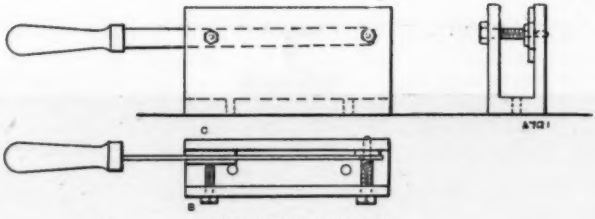


FIG. 2.

FIG. 1. HIGH TENSION ARC DISCHARGE *(See next Page.)*



RIVET-CUTTING APPLIANCE.

with the end against the screw *S* and closing the jaws, any number may be drilled accurately and expeditiously.

MECHANIC.

Rivet-Cutting Appliance.

The illustrations represent elevations and plan of a small machine useful to commutator makers, etc. The frame is of cast-iron, and has two facing strips level with one another. The shear is of best tool-steel, and works on the set screw *A*, which is turned down at one end as shown. Holes are drilled through the boss at *C* to admit the different sizes of wire used for the rivets. The lengths of the rivets are regulated by the set screw *B*. By this method a good number of rivets, all of one length, can be cut off very quickly. The machine is easily made, and can be screwed to the bench at the most convenient place.

ASPIRANT.

High-Tension Arc Discharge.

The accompanying photographs of a high-tension alternating current electrical discharge were taken by their own light with an instantaneous exposure. The arc was produced by short-circuiting a 2,000-volt step-up transformer by means of a fine wire placed across the base of the copper horns. The arc steadily rises, Fig. 1, and lengthens, finally breaking when the top of the copper rods is reached, Fig. 2, an appreciable time being occupied by the ascending discharge, which emits a loud humming sound, and is of a violet colour, peculiarly adapted for acting upon a photographic plate, although to the eye its illuminating effect is inconsiderable. The vapours seen at the base of the horns are due to the volatilisation of the fuse wire employed to start the arc. This automatic extinguishing action of the wedge-shaped spark-gap is much used in lightning arresters and switches on high-pressure aërial transmission lines, but is not considered safe in connection with insulated cable systems, owing to the discharge being of an oscillatory character, which, under favourable conditions of capacity, etc., may subject the insulation to pressures far greater than the normal working limit.

J. W. B.

The guinea award was made last month for the contribution "Worm Gearing."

QUESTIONS & ANSWERS.

Propeller Construction.

Can any reader inform me whether any experiments have been made to compare propellers of equal pitch, surface, and set-back, but made on *horizontal* and *conical* beds respectively (with the strickle board horizontal or inclined)? If these have been made, what is the efficiency of one over the other, and where a copy of these results can be obtained? M. G. C.

Constructing Calorimeter.

Will some reader kindly inform me how to make a calorimeter with which I could calculate the B.T.U.'s in various fuels, principally woods? I may add that it is wanted for use in a country where chemicals of any sort are most difficult to obtain.

M. G. C.

Hydraulic Ram.

How are the various sections of the main lifting ram of a hydraulic coal-hoist fastened together? Give sketches and description.

E. H. D.

REPLY TO J. F. B.

The "Cire perdu" process of Moulding. *(Page 263.)*

The original *Cire perdu* process of moulding is as follows. A loam core is first prepared, the shape and size of the hollow in the intended casting. This is then coated with wax to the thickness that the metal is wanted; this wax is now moulded to the exterior form of the intended casting (which is usually a bust or small statue). Some wires are now pushed through the wax into the core. This model is now placed in an iron moulding box of sufficient size to take it conveniently, and strong moulding sand carefully rammed around it. Provision is made during the ramming for the exit of the wax, which channel also serves for the admittance of the molten metal later. The mould is now put in a drying stove and exposed to a good heat, which melts the wax and causes it to run out at the hole made for that purpose. The core is supported by the wires before mentioned. It only now remains to pour the metal, and the process is complete. I have seen a modification of the process carried out on a fairly large scale for castings in a white metal alloy. The job was to cast some urns or vases weighing about seven or eight hundredweight each. The operation was as follows:—As much of the entire pattern as would lift from the sand in the ordinary way was prepared in sections to draw from the mould, but the main part of the pattern was sculptured with figures in relief, so a gelatine mould was taken off this part. A plain wooden body was made, smaller than the body of the pattern; over this was made a tin jacket to easily draw off. This body was placed inside the gelatine mould and wax was cast round, thus giving a wax pattern supported by the wooden body. This was now rammed in the mould in the ordinary way and the body withdrawn, leaving the wax embedded in the mould backed by the tin jacket. The use of this jacket was to let the heat of the stove get directly at the wax. The mould was now put in the stove, with a tray underneath to catch the wax. When the mould was dry and the wax all melted out, it was taken from the stove and finished. The mould was next placed over a separatly prepared core in the usual way, and with all due precautions, cast.

T. N.

REPLY TO R. E. H. *(Page 353.)*

The horse-power of an engine does *not* depend on the length of the connecting-rod. If the engine is to run at a high speed, such as a dynamo engine, the connecting-rods are short. The effect of using a short rod is to increase the effort on the crank-pin during the first half of the stroke, and to decrease it on the latter half, thus causing greater irregularity in the tangential pressure on the crank-pin and greater stress on the guide-bars. But in high-speed engines the effect of inertia has to be considered. A long connecting-rod would have too much weight, thus causing a heavy strain on the bearings and moving parts, when the reversal of forces takes place at the dead centres. This would

soon wear the brasses, causing a knock at every stroke. By using shorter and consequently lighter rods, these defects are mitigated to a certain extent. In high-speed engines the inertia effect is the most important, and therefore is considered first, though the rods must not be made too short, the ratio of the length of the connecting-rod to crank being not less than 4 to 1 (Unwin). But with a slow-speed engine, such as a pumping-engine, long connecting-rods are used, the inertia effect being comparatively small, due to the slow speed; and the equalising effect of the longer rod is considered first in such a case.

E. H. D.

REPLY TO Q. E. F. *(Page 353.)*

Q. E. F. states that the output of the plant is 210 volts at 300 amps., which is equal to 63 kilowatts, and yet he says that the engine is coupled to an 85-kilowatt dynamo, which I presume means that the load factor employed is equal to 74 per cent. The information given is not sufficient to give the quantity of coal consumed very correctly, but the following may be taken as the approximate amount. Basing the first calculation on the total 130 b.h.p. and assuming the engine is non-condensing, an average value of steam consumption would be 35 lbs. per b.h.p. per hr., and the evaporative power of one pound of coal may be taken to be 7 lbs. of water, then :—

$$\frac{130 \times 35}{7} = 650 \text{ lbs. of coal per hour.}$$

$$= 2{\cdot}9 \text{ tons per 10 hour day.}$$

Now taking the load factor of 74 per cent. we get 94·2 b.h.p., and with the same data as above we find that the coal consumption is :—

$$\frac{94{\cdot}2 \times 35}{7} = 471 \text{ lbs. of coal per hour.}$$

$$= 2{\cdot}1 \text{ tons per 10 hour day.}$$

Something extra should be added for lighting and, if necessary, banking up; but this quantity depends on the working conditions.

A. K.

REPLY TO W. W. *(Page 165.)*

In reply to W. W., a reliable seal for electricity meters would consist of a moulded glass screw having a solid head, the surface of which would consist of two inclined planes or double scroll, as shown at Fig. 1. This would be capable of being turned in one direction only—*i.e.* that for tightening. A square hole in the back of the screw, within, say, $\frac{1}{8}$ in. of the face, would provide a means of unscrewing, by punching through the thin section, should the company at any time desire to withdraw the screw. I think the above would fulfil the requirements, being brittle, not affected by time or moisture, and can be inserted when meter is in position.

F. S.

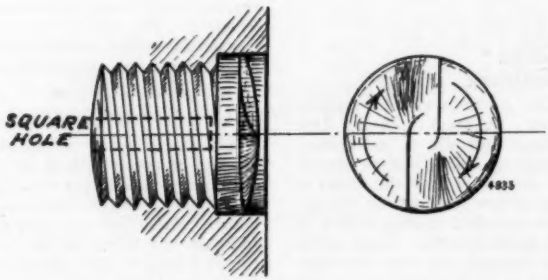


FIG. 1.